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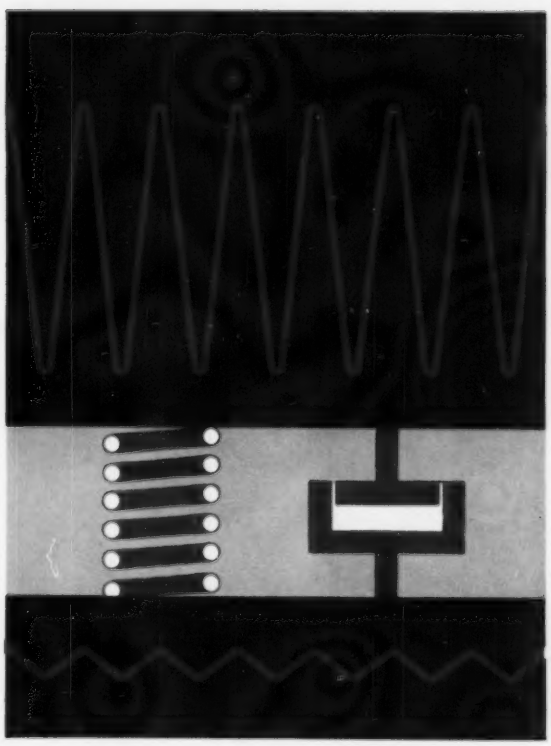
the magazine of energy systems engineering



VIBRATION ISOLATION

a 16-page *special* report . . . 201

Why new NEMA Standards spell tighter fuse performance . . 71

Specific speed is key in picking the right centrifugal pump . . 75

Liquid metals show new promise for nuclear plants 78

Fire-resistant lubes prove out in pipeline gas turbines 83

How industrial-boiler designs affect air pollution 86

Precast manholes save man-hours at Watervliet Arsenal . 89

Balancing tests on new turbine spindles raise reliability 90

The Geysers power plant gets set to take on electrical load . 93

Figure emergency capacity of your air receiver 102

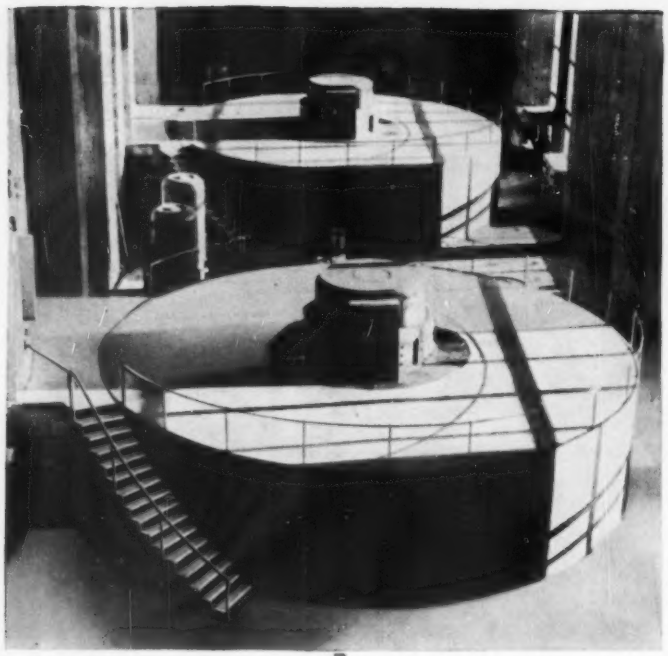
Briefs of technical papers on oil, grease and F-R lubes 106

Primer on the Steam Tables . 158

Three hookups for ct's 217

PVC pipe cuts maintenance at Florida Keys Co-op 218

Up-to-date instrumentation improves accuracy of generator-load tests at L.I. Lighting . . 220



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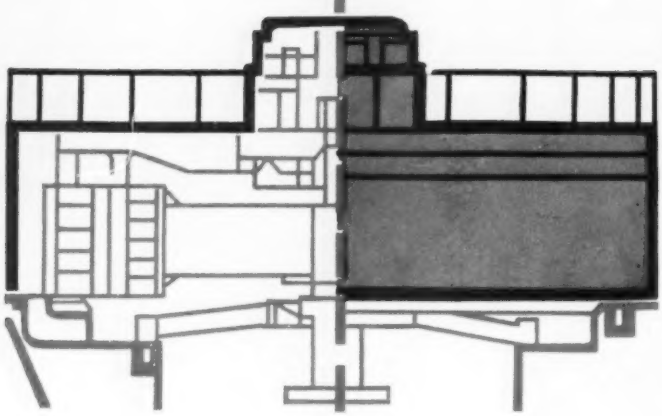

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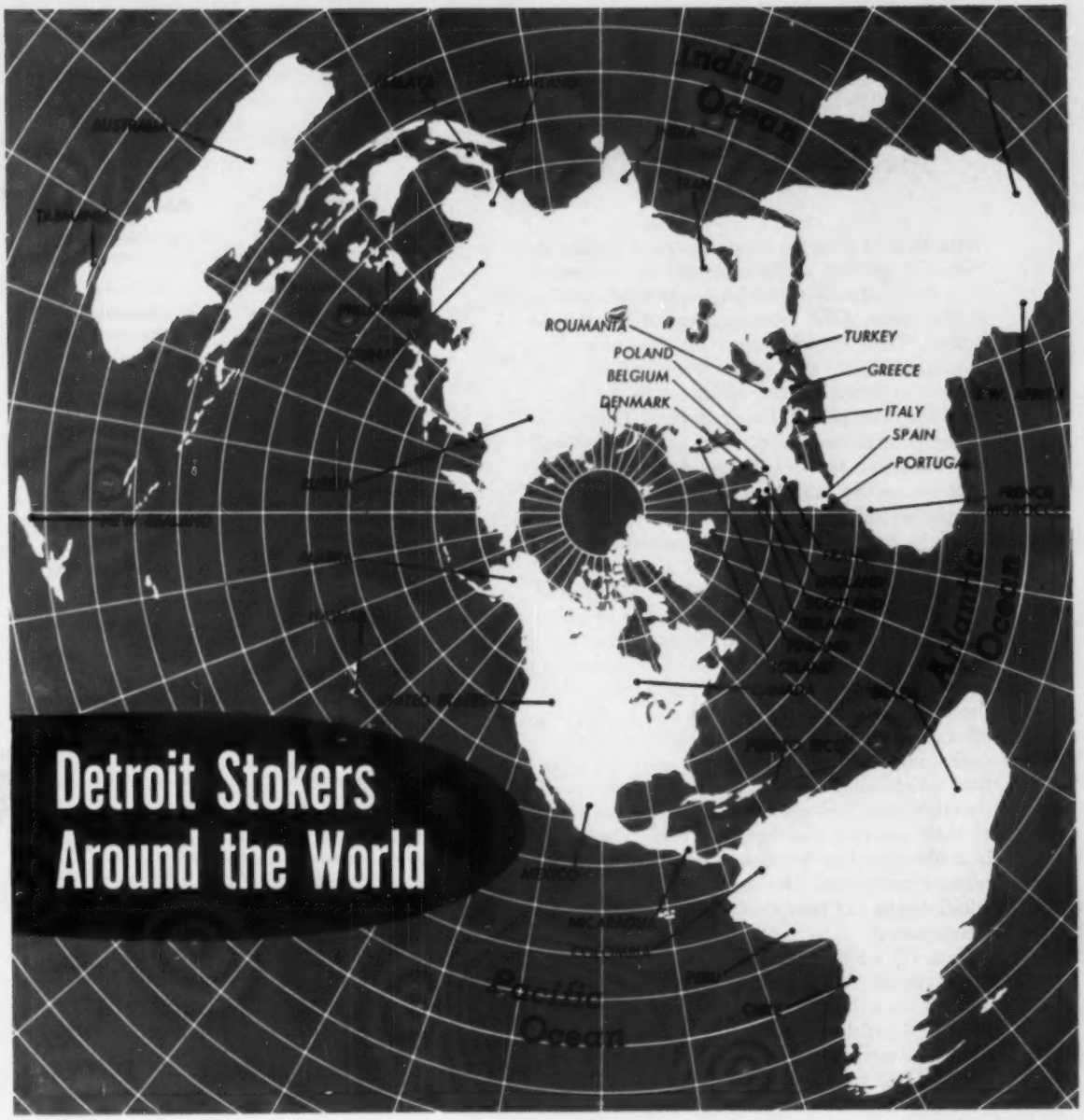

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speaking of **Power**

Who should own the main substation feeding an industrial plant — utility company or customer? This was the timely theme for one technical session at the recent AIEE Summer General Meeting in Atlantic City. Electrical engineers from many top industrial plants, and a few from utilities, took active part in this meeting sponsored by the Industrial and Commercial Power Systems Committee.

The general conclusion, after papers were read and discussion temporarily ended, was one to be expected: neither utility nor industrial relishes making the capital investment in primary subs if they can help it. And that's easy to understand since a 5000-kva main sub could run about $150,000 installed. In a recent marketing survey we found $96 million was spent by POWER readers in industrial plants just for major gear in main subs.

Many utilities want to get out of the industrial-substation business, ending their prime responsibilities atop the incoming disconnect switch. Lopping off a sub at the end of their distribution lines cuts capital investment while reducing outlay for operation, maintenance and repair. Some industrials, on the other hand, look upon the primary sub as a part of their electrical-distribution system. Ownership is made attractive because of the accompanying reduced power rate plus greater freedom during initial design and later flexibility in operation and maintenance.

Naturally we were pleased to see this matter discussed at an AIEE meeting because of its importance to a large segment of POWER's readers. In a PTG article some time back (Feb 1959, pp 66-68) we saw a trend shaping up in favor of self-ownership of primary subs. If this trend toward self-ownership continues—and we have every reason to believe it will—energy-systems engineers with industrial-plant responsibilities will be increasingly concerned with designing and equipping main subs.

Lon Rowley

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POWER (with which are consolidated *Science and Industry, The Engineer Review, The Engineer, The Stationary Engineer* and *Operating Engineer*) is published monthly by McGraw-Hill Publishing Company, Inc, James H McGraw (1860-1948), Founder. PUBLICATION OFFICE: McGRAW-HILL BUILDING, 330 W 42nd St, New York 36, N. Y. See box, right, for directions regarding subscriptions or change of address.

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United States subscription rate for individuals in the field of the publication $3.00 per year, single copies $1.00, unless otherwise indicated. Canada; $5.00 for one year. Foreign; $15.00 for one year. Second-class

In Power this month

AUGUST 1960 • VOL. 104 • NO. 8 • 78TH YEAR

Editorial: Want to cut your reading time? 67

DESIGN AND EQUIPMENT APPLICATION

New NEMA standards spell out tighter fuse performance 71
Use specific speed to pick the right centrifugal pump for your job 75
Liquid-metal systems show new promise in nuclear plants 78
Fire-resistant lubes prove out for pipeline gas turbines 83
How industrial boiler designs affect formation of air pollutants 86
Precast manholes save man-hours and dollars at Watervliet Arsenal 89
Spindle tests locate rotor-stability problems, raise turbine reliability 90
The Geysers magmatic-steam plant gets set to take on load 93

DEPARTMENTS

Nuclear notes: News briefs on the latest developments 96
Comment: Two pages reserved for readers' remarks 98
Data sheet: Figure emergency capacity of your air receiver 102
Technical briefs: Digests of latest engineering papers for busy power men 106
New literature: Yours simply for mailing postage-free Reader Service card 119A
Plant equipment news: Your information center for new products and materials 134
Thermo refresher: Practice makes perfect using the Steam Tables 158
Marmaduke Surfaceblow tackles some balled-up furnaces 166
Powerscope: A selective look at this month's power-field happenings 180
Calendar of events 188 *Appointments* 192
Bookshelf 196 George *Edwards* 198

PLANT MAINTENANCE AND MANAGEMENT

VIBRATION ISOLATION: a 16-page *special report* 201
Spring mounts often include leveling and damping action 206
Rubber in action rolls with the punch 208
Inertia blocks take the heavy punishment 212
Don't forget the *flexible connectors* 213
Tapes and compounds damp vibration at the end of the line 215
Structural damping rounds out the picture 216

Plant electrical fact file: Three current-transformer hookups 217
PVC pipe cuts diesel-plant maintenance at Florida Keys Electric Co-op 218
Long Island Lighting Co improves generator-load measurements 220
Plant problems: Here's how Power readers tackle them 222
Practical ideas to keep your plant running at peak efficiency 226

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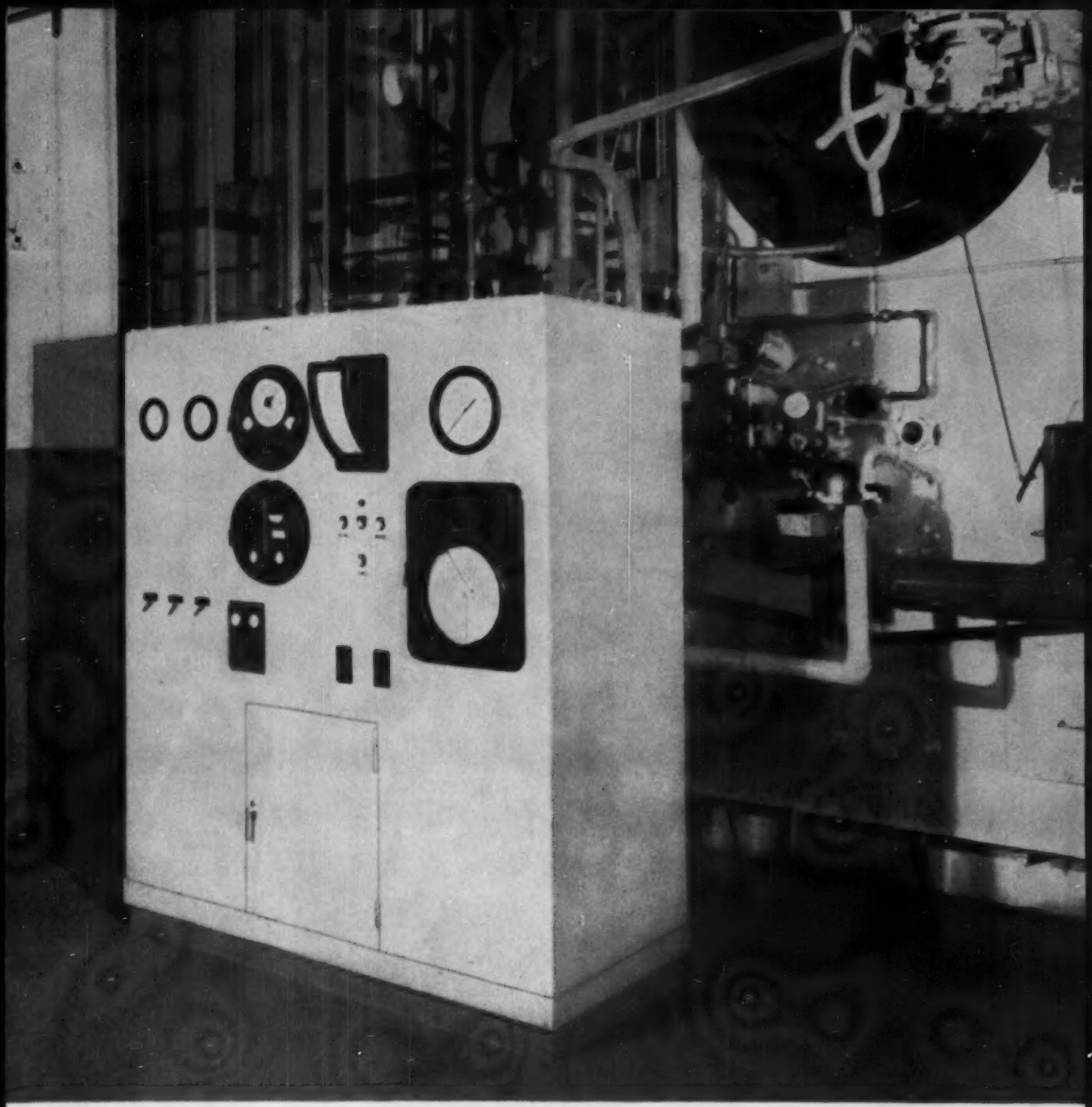
New B&W Boilers Cut Heating Costs 22% for Country's 3rd Largest Building

American Furniture Mart Corporation replaces 3 previous boilers with 2 B&W package units . . . Heats 29 Million cubic feet at fuel cost saving of 22%

The American Furniture Mart dominating Chicago's skyline with a 17 story building topped by a 33 story tower . . . has 29 million cubic feet of space to be heated. It is the largest commercial building in the world devoted to a single industry, home furnishings. Throughout the year, it is the national purchasing center for thousands of retail stores, large and small, and at peak markets, upwards of 45,000 buyers and sellers shop its display spaces. The recent installation of two B&W boilers . . . in place of three previous units . . . provides all the steam necessary for this large heating job at a fuel cost saving of 22%. Additional economies can be realized because fuels can be switched in a matter of minutes

For more facts circle 205 on Reader Service card, p. 119



to use the fuel most economical at any given time. Moreover, these new boilers are fast steaming . . . put out plenty of heat in a hurry even after being turned off all night.

In addition to cutting fuel costs, a savings that will pay for the units in five years, these B&W package boilers cut space requirements in half and require fewer men to keep them in operation. It is interesting to note, too, that these boilers were installed during the height of the heating season . . . with minimum loss of heat to the building's occupants during the changeover period. Furthermore, management knows that any time in the life of the boiler — 10, 20 or 30 years hence — B&W's nation-wide service organization will be promptly and economically available if needed.

Providing the efficiency, economy, and service necessary to heat the country's third largest building economically is further evidence-in-action of dependable steam generation by B&W. Whatever your steam requirement . . . whatever your most economical fuel . . . B&W has the boiler best suited to your heating application. For information, contact your local B&W representative. He has all the facts on your area. The Babcock & Wilcox Company, Boiler Division, Barberton, Ohio.

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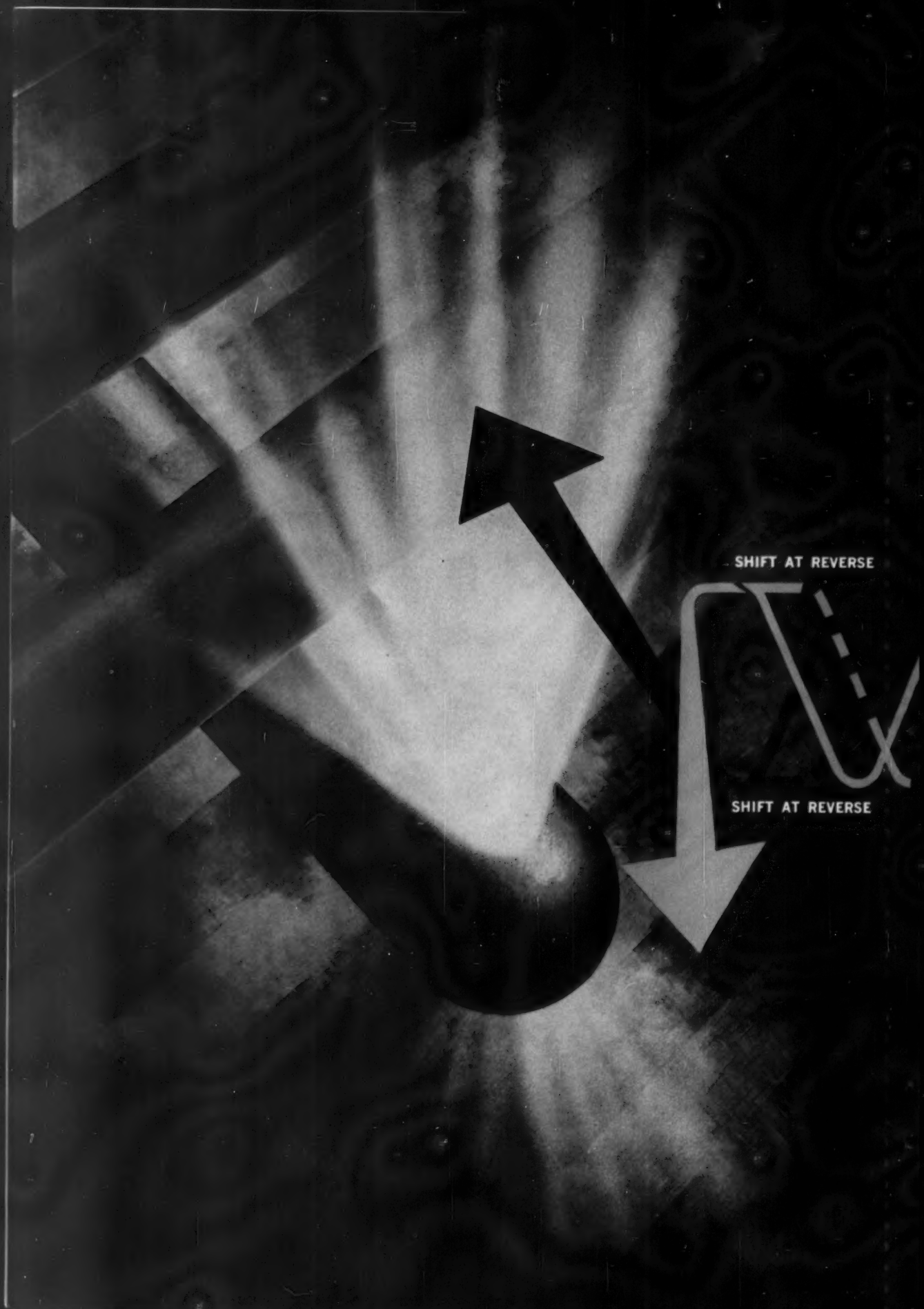
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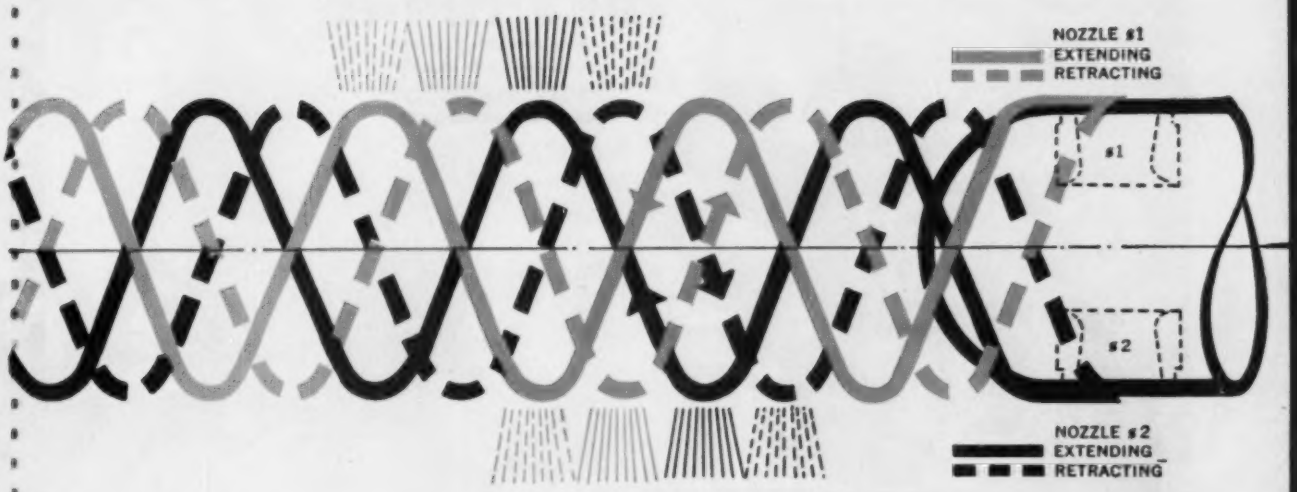

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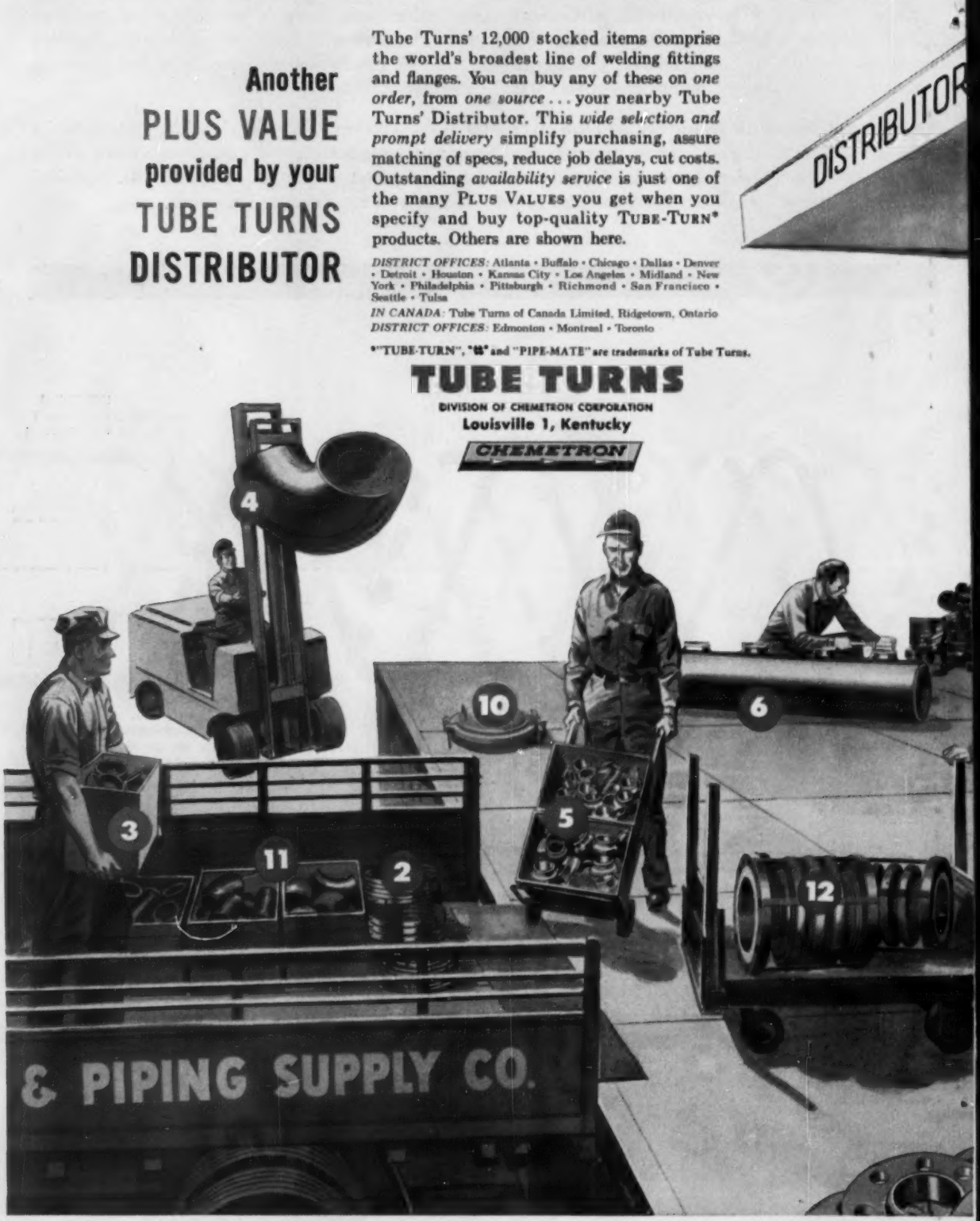

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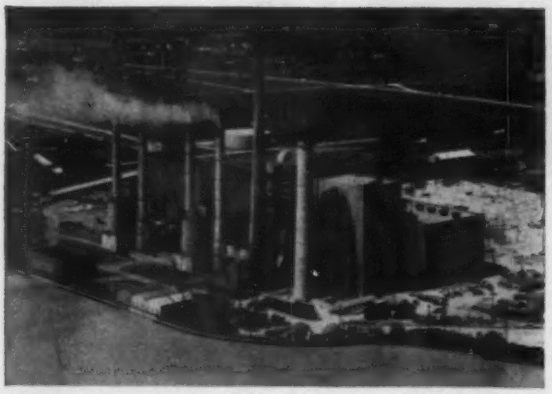
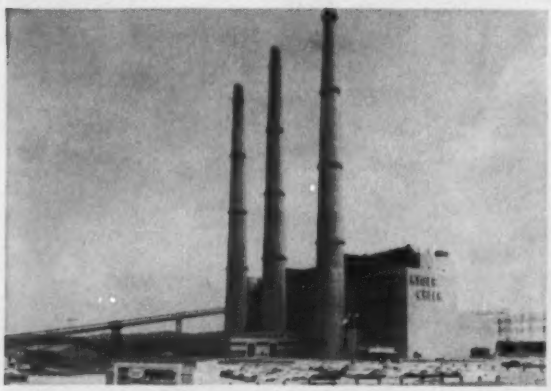
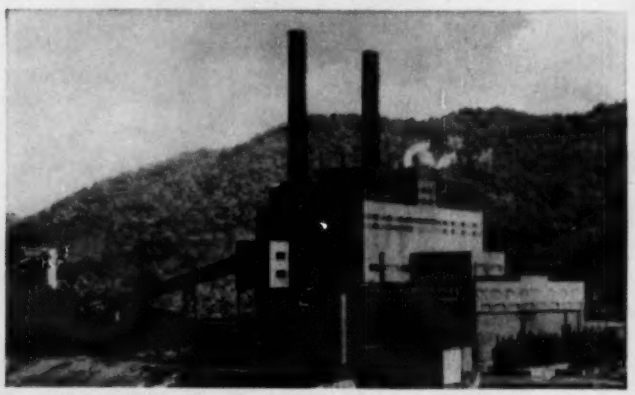


ST. CLAIR (The Detroit Edison Co.)—top 11, 1954-1958, averaging 9222 btu/kwhr.

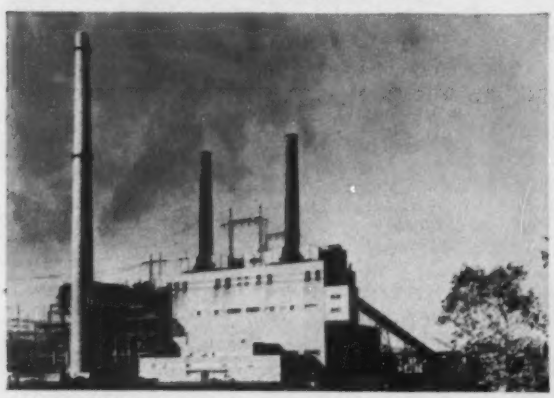
TANNER'S CREEK (Indiana & Michigan Electric Co.)—top nine, 1954-1958, first in 1956, averaging 9204 btu/kwhr.



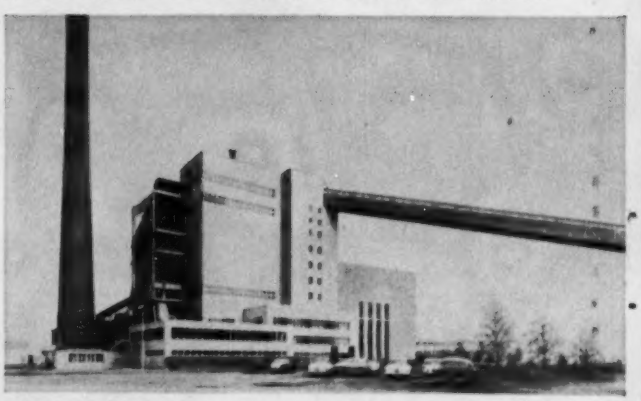
KYGER CREEK (Ohio Valley Electric Corp.)—top six, 1955-1958, first in 1955, averaging 9164 btu/kwhr.



KANAWHA RIVER (Appalachian Power Co.)—top three, 1954-1958, first in 1954 and 1957, averaging 9128 btu/kwhr.



MUSKINGUM RIVER (Ohio Power Company)—top five, 1954-1958, averaging 9216 btu/kwhr.



BAY SHORE (The Toledo Edison Co.)—top ten, 1956-1958, averaging 9241 btu/kwhr.

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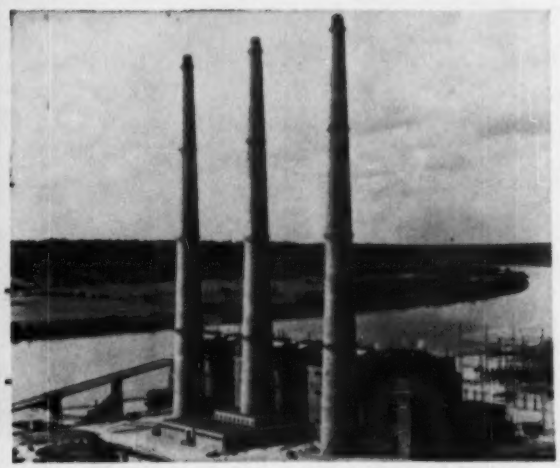
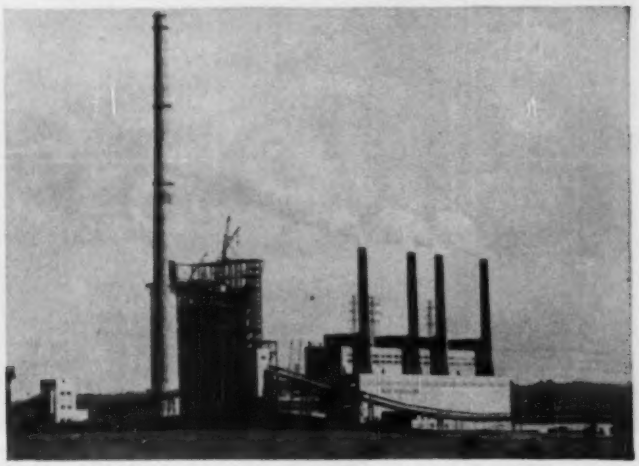


CLIFTY CREEK (Indiana-Kentucky Electric Corp.)—top five, 1955-1958, averaging 9155 btu/kwhr.



PHILIP SPORN (Appalachian Power Co.—Ohio Power Co.) —top fifteen, 1954-1958, averaging 9378 btu/kwhr.

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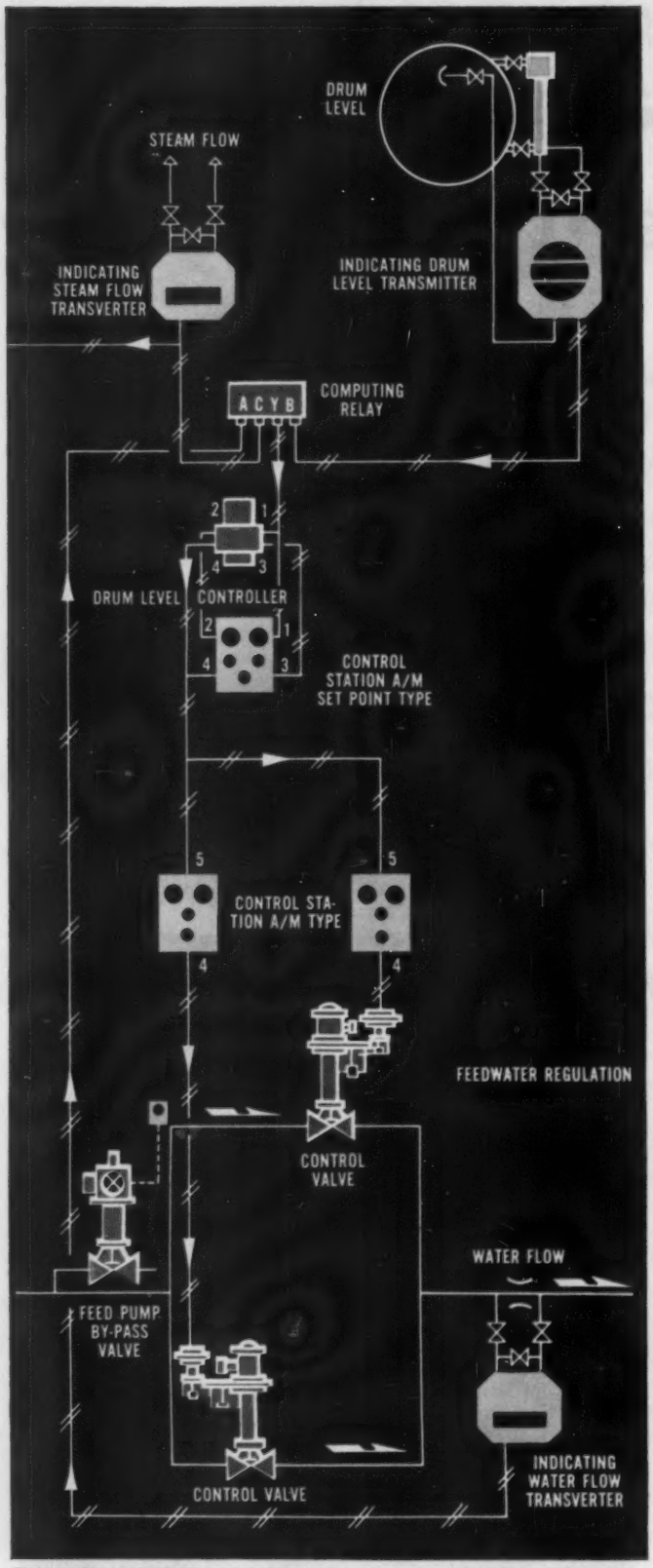
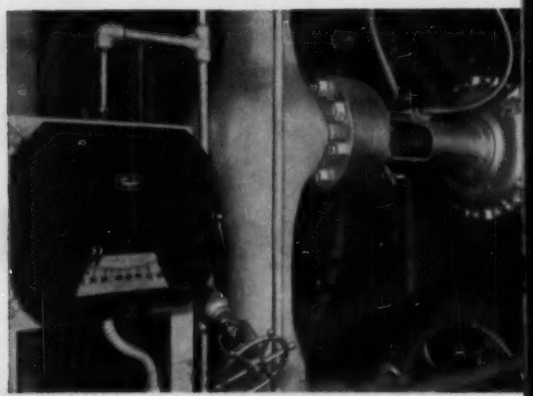
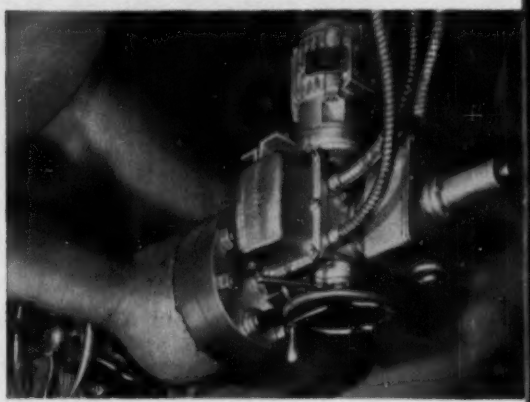


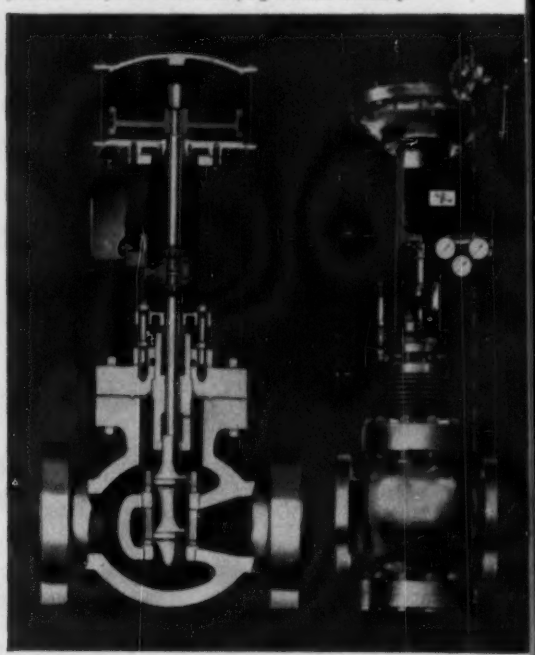
Three influence feedwater regulation is just part of a complete Copes-Vulcan boiler control system installed at a pace-setting utility station. Feed to boiler is modulated by steam flow, feedwater flow, and drum water level.



Copes-Vulcan recirculation control protects boiler feed pumps. When pump discharge falls below a certain level, a diaphragm-operated by-pass valve opens to assure sufficient flow to prevent overheating of the pump.



A feedwater and heater by-pass valve is shown above. Also, a Copes-Vulcan control valve is installed in each of the two main boiler feed lines. These valves handle pressure drops of over 2600 psig without difficulty.



Versatile control valves feature simplicity of design. Piston-type CV-P (left) is ideal for high-duty service. Diaphragm-type CV-D (right) is designed for remote control service. All Copes-Vulcan valves are tailored to the job.

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BLAW-KNOX

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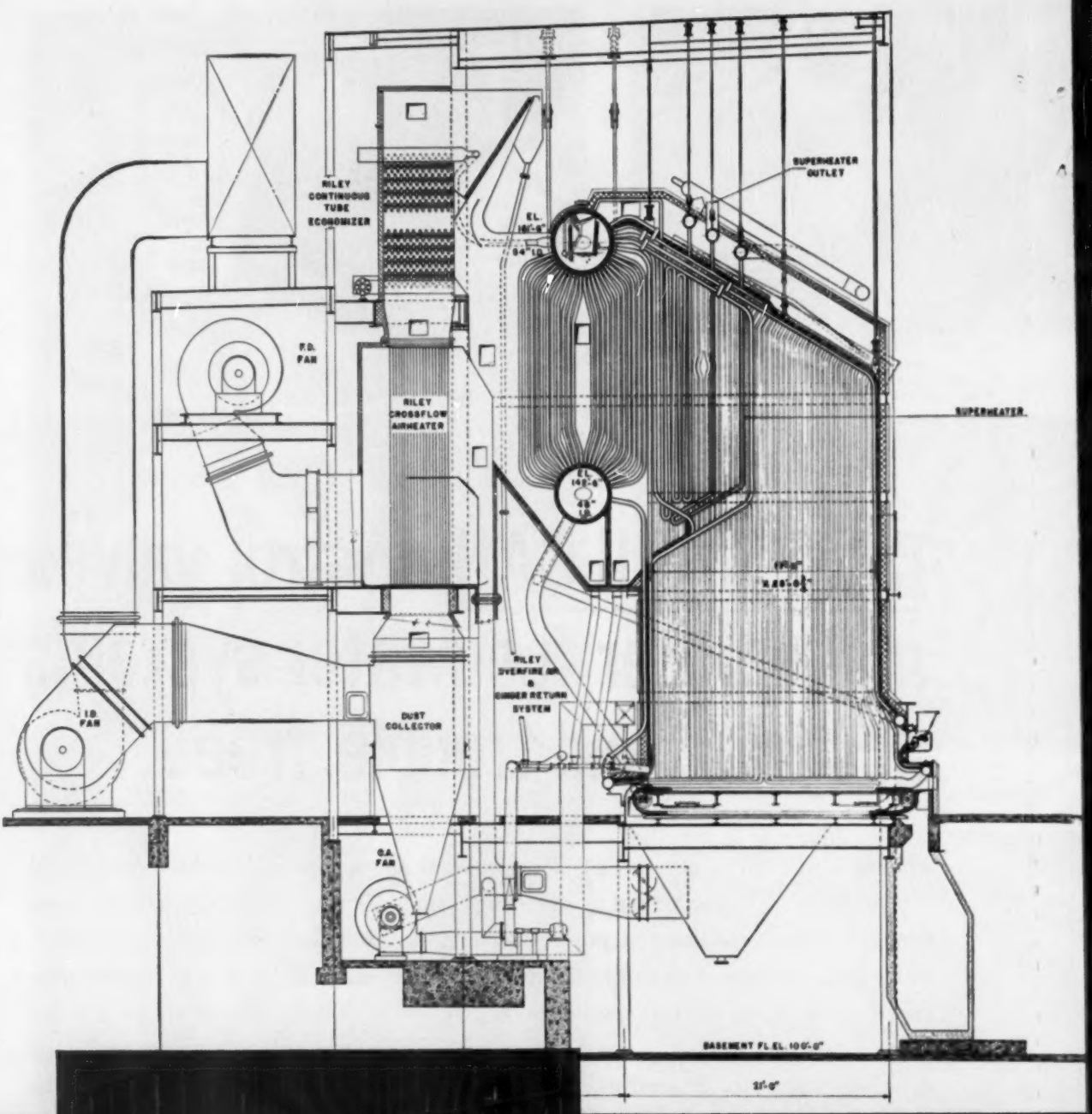


RILEY RX BOILER UNIT — RILEY STOKER CORPORATION

Continuous Unit Capacity . . 250,000 lbs. steam per hour
Peak Capacity . . . . . 275,000 lbs. steam per hour
Operating Pressure. . . . . 415 psi (Future 850 psi)
Steam Temperature . . . . . 750F (Future 900°)

REPUBLIC ELECTRUNITE BOILER TUBES meet the severe curvature of boiler design. Full normalizing, uniform wall thickness, and true concentricity assure easy workability and in service dependability. Bends are smooth and uniform. Rolling-in operations are easier. Results: greater savings in installation time and operating costs.

For more facts circle 210 on Reader Service card, p. 119

more power for the city of Painesville...with

REPUBLIC ELECTRUNITE BOILER TUBES

Push a button, flip a switch—power to operate schools, factories, and the convenience of modern living originates in the boiler units of power plants. And a great share of boilers are constructed of Republic ELECTRUNITE® Boiler Tubes.

Painesville, Ohio, a growing community in the heart of industrial America, has just installed an additional Riley RX Boiler Unit in its municipal power plant.

Designed, engineered, erected by Riley Stoker Corporation, Worcester, Massachusetts, the RX has a continuous unit capacity of 250,000 lbs. of steam per hour, peak capacity of 275,000 lbs. of steam per hour and an operating pressure of 415 psi at a steam temperature of 750F. The RX Unit is fired by a Riley Traveling Grate Spreader Stoker.

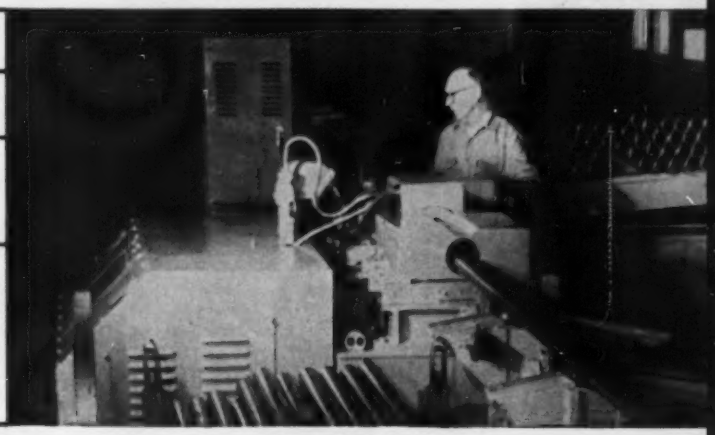
Republic ELECTRUNITE Boiler Tubes are accepted by boiler designers, engineers, and manufacturers. ELECTRUNITE is produced to meet ASTM specifications, the ASME Boiler and Pressure Code, and boiler insurance requirements.

For boiler, heat exchanger, condenser, or evaporator tubes, get ELECTRUNITE facts first-hand. Call your Republic representative, or write direct.

FARROWTEST REJECT TABLE

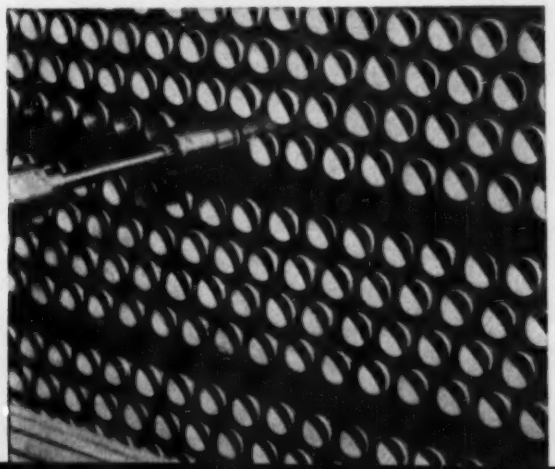
Wall Thickness (B.W. Gage)	Minor dimension of the defect (Length or Depth)	Defective Area (Length; Depth Plane)
20	.006"	.0025 sq. inches
18	.006"	.003 sq. inches
16	12½% of wall	.003 sq. inches
14 and 13	12½% of wall	.004 sq. inches
12 and heavier	12½% of wall	.005 sq. inches

FARROWTEST detects and rejects not only tubing containing defects which completely penetrate the wall; but also tubing with defects equal to, or greater than, those shown in this table. For irregular defect shapes, a tube with defect area equal to or greater than shown above is rejectable. Where required, sensitivity of FARROWTEST equipment can be calibrated to reject defects of lesser specified area than shown in table, at extra cost.



FARROWTEST—QUALITY YOU CAN MEASURE. Not a laboratory theory, not a mere inspection tool, but an exclusive production test that detects and rejects tubing containing defects of critical size. FARROWTEST is offered as an alternative to other less positive tests in accordance with the table above, at no extra cost.

REPUBLIC ELECTRUNITE STAINLESS STEEL HEAT EXCHANGER TUBING resists corrosion and provides long trouble-free service for main surface condensers in utility power plants where water is used directly from natural sources. Call your Republic representative for additional information, or send coupon.



REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
DEPT. PO-9758
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send more information on the following products:

☐ Republic ELECTRUNITE Boiler Tubes ☐ FARROWTEST®
☐ ELECTRUNITE Stainless Steel Heat Exchanger Tubing

Name_____ Title_____

Firm_____

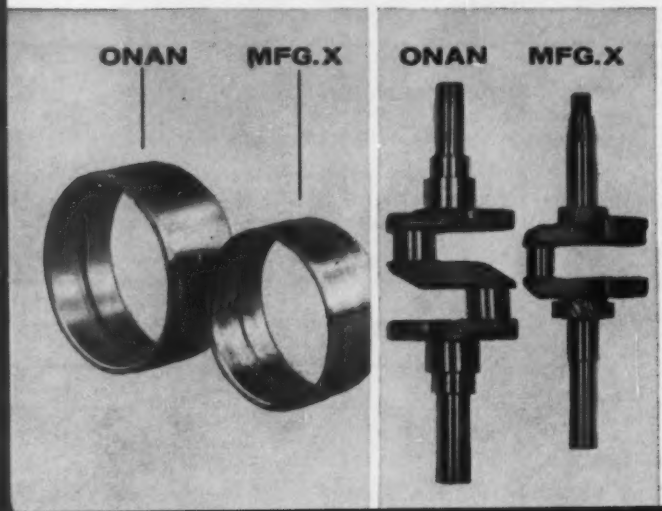
Address_____

City_____ Zone____ State_____

Onan Electric
full power after

Typical Onan torture test—tougher by far than normal usage—proves Onan's ability to deliver on any job.

Generous design assures longer life—Husky Onan has double the bearing area of many equivalent rated engines . . . plus larger, stronger crankshaft to minimize breakdown and to give you longer, trouble-free service between overhauls.



Exacting standards govern manufacture—Years of specialized experience and extensive testing facilities control the quality of Onan Power Plants. Over 1000 different types and sizes of plants are produced by this same, careful method at Onan.

Plant still delivers 12,197 hour test run!

Run equivalent of 487,888 miles... killed and started... tortured, tested, retested... Onan Test Plant #1068 still delivered full-rated power

A grueling endurance test that lasted one year, nine months and 12 days could not stop Onan Test Plant #1068. Development engineers used this production-built unit as a testing laboratory. And after it was all over, it still generated the full rated power promised on the nameplate. Proof that Onan's exacting standards and production testing give you a power plant with long, dependable service built in.

Over 1,700 other endurance tests have been run by Onan development engineers. Here's where every design feature and part had to prove itself before it could become a part of the Onan you buy. In addition, every type and size Onan Plant is tested under all operating conditions which affect its performance.

Hours of running in and testing under load are given every Onan before it is shipped. An independent testing laboratory retests Onan-tested Plants and certifies Onan testing methods—double assurance that every Onan will deliver its full nameplate rating. Only then does an Onan qualify for its Performance Certified Guarantee.

You buy *proven* performance when you buy an Onan Plant. See your Onan representative. You'll find his name in the telephone classified section in every major city, or write direct.

ONLY ONAN GIVES YOU THIS CERTIFICATION

PERFORMANCE CERTIFIED
We certify that when properly installed and operated this Onan electric plant will deliver the full power and the voltage and frequency regulation promised by its nameplate and published specifications. This plant has undergone several hours of running-in and testing under realistic load conditions, in accordance with procedures certified by an independent testing laboratory.
D. W. ONAN & SONS INC.
Minneapolis 14, Minnesota
Onan

Onan®

World's Leading Builder of Electric Power Plants

D. W. ONAN & SONS INC., 2626 UNIVERSITY AVE. S.E., MINNEAPOLIS 14, MINN.

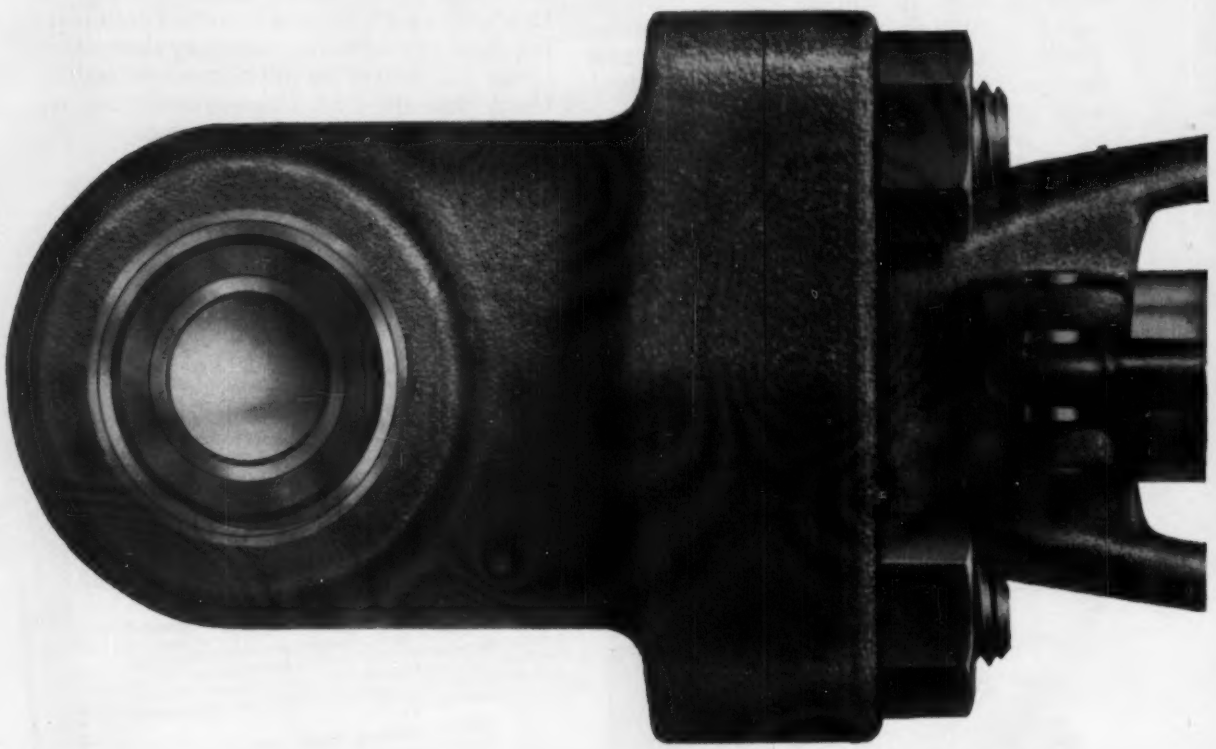
For more facts circle 211 on Reader Service card, p. 119

Reporting more news from...

CRANE
DIRECTION '70

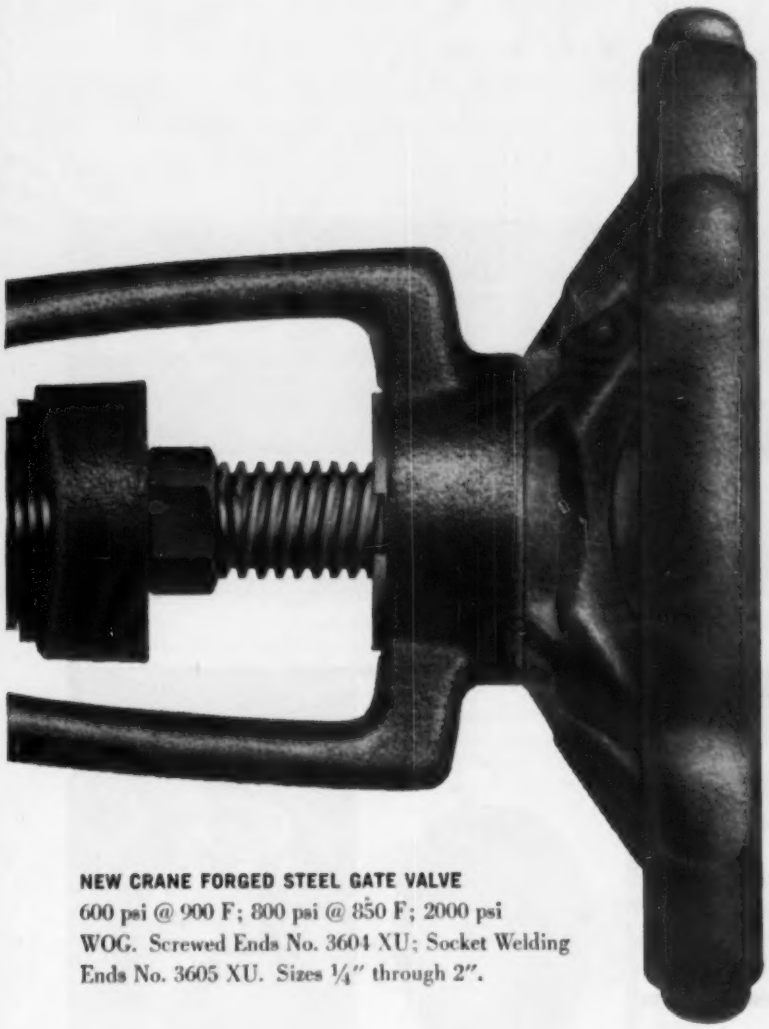
...a fast-moving program of planned expansion, product development, and streamlined distribution to help our customers meet the competitive challenges of the Sixties.

COMPLETELY



REDESIGNED!

THE NEW SMALL FORGED STEEL GATE VALVE



NEW CRANE FORGED STEEL GATE VALVE
600 psi @ 900 F; 800 psi @ 850 F; 2000 psi WOG. Screwed Ends No. 3604 XU; Socket Welding Ends No. 3605 XU. Sizes ¼" through 2".

This is a whole new valve, not just one with a new feature added. This redesign incorporates all the features you told us you wanted plus a few others we know will make this valve a better buy in terms of longer service life, less maintenance, easier and faster servicing.

Like the new "bow-leg" yoke, which for the first time gives you plenty of hand room for easy stuffing box maintenance. And like the long-life braided asbestos packing, with Inconel wire insert. The "universal" trim that can be used for either oil or steam, eliminating many of your stocking problems. The spiral wound stainless steel bonnet gasket with asbestos filler, made blowout-proof with a male-female joint.

But what we really want you to remember, more than any single feature, is that this Crane valve is the newest—all new—valve on the market . . . well worth considering when you need small, high-pressure steel gate valves. We'd like you to compare this new valve with any other comparable valve feature for feature.

Your local Crane distributor has technical literature and a complete selection of these valves right in stock. Call him on small steel gates. In fact, he's your best bet to call no matter what valve you want because he carries the broadest line of quality valves in the world.

CRANE®

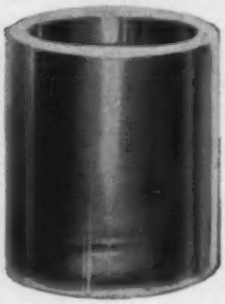
CRANE CO., INDUSTRIAL PRODUCTS GROUP
4100 S. KEDZIE AVE. • CHICAGO 32, ILL.
VALVES • ELECTRONIC CONTROLS • PIPING
PLUMBING • HEATING • AIR CONDITIONING

For more facts circle 212 on Reader Service card, p. 119

CORNING INDUSTRIAL GLASSWARE FOR EVERY JOB

Name your problem, and there's a Corning Industrial Glass Product to fit it. They're stocked locally, too, by most industrial distributors and mill supply houses. Carefully engineered, they are designed to withstand temperature change, mechanical shock, corrosion, and every hazard they'll be exposed to. You've a wide selection, too. Sight glasses, for example. They're made for temperatures up to 500°F, pressures up to 300 psi. But don't wait for emergencies to threaten production, create unnecessary down time. Stock up with replacements now . . . at least *three* for each installation. Then you'll be sure.

Lubrication inspection



PYREX® Lube Glasses

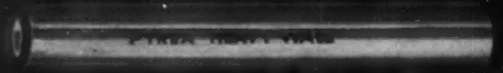
Up to 100 psi

Corning® Standard Gauge Glasses

Extra visibility

PYREX® Red-Line Gauge Glasses

Higher pressures



PYREX® Heavy-Wall Gauge Glasses

Higher temperatures

PYREX® High-Pressure Gauge Glasses

Heavy duty

Macbeth® Flat Glasses

Furnaces, reactors, pressure vessels

PYREX® Sight Glasses

Visible discharge

PYREX® Oil Cup Glasses

CORNING GLASS WORKS

CORNING MEANS RESEARCH IN GLASS.

For more facts circle 213 on Reader Service card, p. 119

circle 214 on Reader Service card, p. 119 ➤

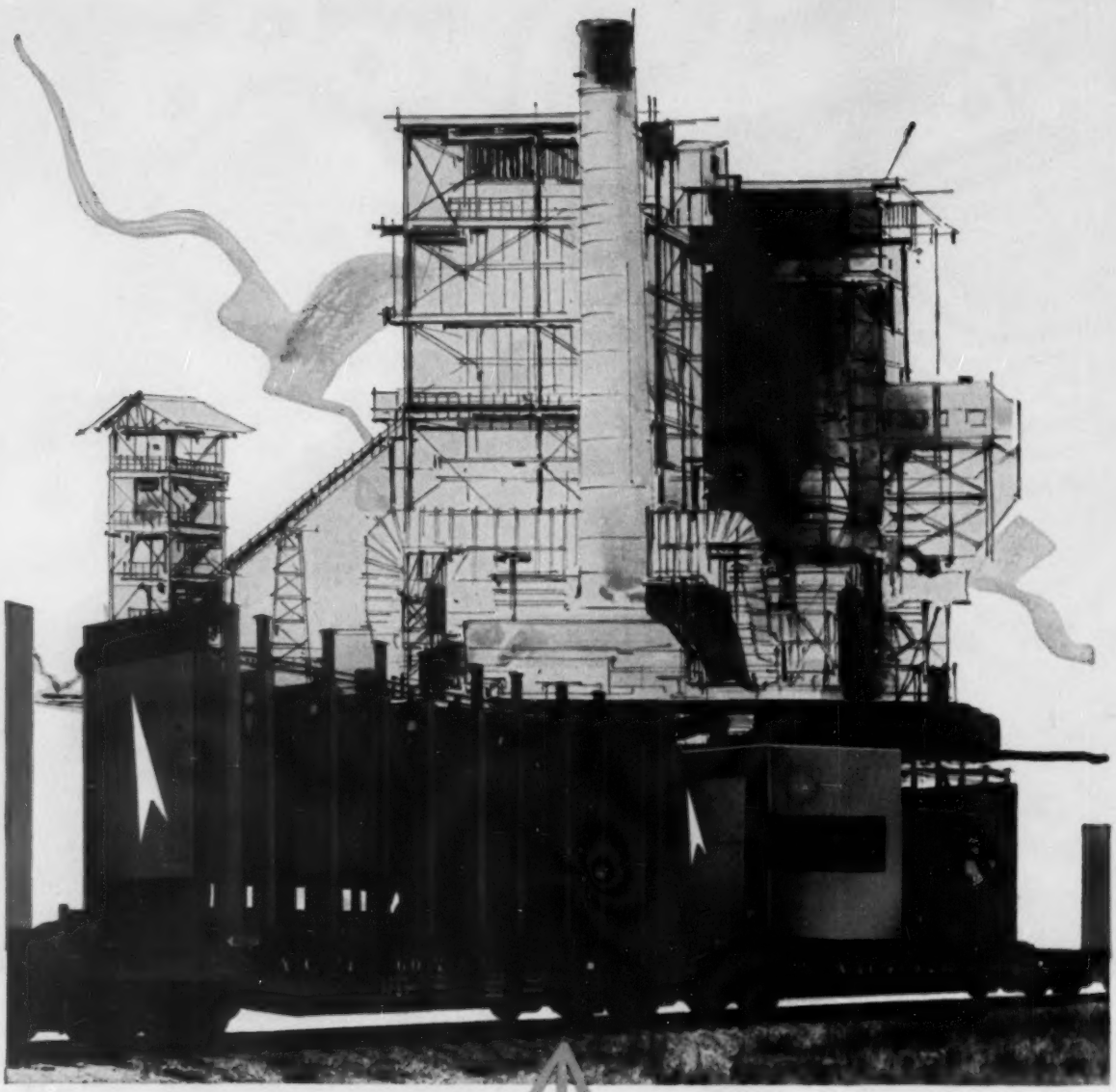
If coal piles like this should ever be exhausted, American Industry would grind to a virtual halt — for coal still provides more "Go Power" than all other fuels combined... You can safely rely on Beacon as a dependable source to keep YOUR fuel supply always ahead of need. The 18,000,000 yearly tons we handle include a wide variety of coals with a complete range of properties in any quantity you require. A central control laboratory for combustion studies is supplemented by quality control laboratories at each of our larger mines. Preparation facilities are modern, teletype service connects our sales offices with major mines so that orders can be immediately placed, traced and expedited, and our trained Representatives understand combustion problems, and work their hardest to help you solve them.

BEACON COAL

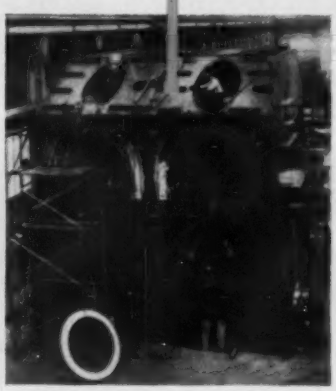
EASTERN GAS AND FUEL ASSOCIATES

PITTSBURGH • BOSTON • CLEVELAND • DETROIT • NEW YORK
NORFOLK • PHILADELPHIA • SYRACUSE

For New England: New England Coal & Coke Co., For Export: Castner, Curran & Bullitt, Inc.



Sectional shipping cuts condenser erection time



40%—American-Standard* surface condensers are built complete in our plant in shipping-size flanged sections. Prior to shipment, sections are mated, accessories mounted and entire units are match-marked. Then the sections are separated for shipment. On the job site, these sections are reunited and connections made. Erection time and costs are substantially reduced over the old method of sending premachined and preformed parts. This is one of many benefits you receive in American-Standard surface condensers. Get the whole story from one of our product specialists. There is an office nearby to serve you. American-Standard Industrial Division, Detroit 32, Michigan. In Canada: American-Standard Products (Canada) Limited, Toronto, Ontario.

*American-Standard and Standard® are trademarks of American Radiator & Standard Sanitary Corporation

American-Standard Products

AMERICAN-Standard
INDUSTRIAL DIVISION

AMERICAN BLOWER PRODUCTS • ROSS PRODUCTS • KEWANEE PRODUCTS

For more facts circle 215 on Reader Service card, p. 119

ROBVON
BACKING RING COMPANY

ROBVON BACKING RINGS

SIMPLIFY PIPE WELDING IN ADVERSE FIELD CONDITIONS

FAST•EASY•FIT-UPS

TYPE CCC

Designed for quick easy alignment of pipe where the variation in inside diameters is relatively great. Chamfered NUBS allow close tolerance fit-up and CLEAN STRIKE OFF. The ROBVON NUB automatically sets root gap. ROBVON rings are beveled to assure non-restricted fluid flow.

TYPE CC

Designed to allow quick easy alignment of pipe where the inside diameters are slightly out of round. The welder has the choice of "STRIKING OFF" the NUBS or leaving them intact to be melted into the weld mass of the first roof pass.

TYPE C

Designed for precise close tolerance fit-up. Type "C" NUBS automatically sets root gap. The NUBS melt with the metal to give complete penetration and fusion.

PLAIN TYPE

Rings have flat outer surface with beveled internal edges and flat inner land.

MACHINED RINGS

Robvon also manufactures machined rings to customer's specifications. All fabricated solid machined rings x-rayed.

Available in carbon steel, wrought iron, chrome alloys, stainless steel, aluminum and copper. Write for full information.

675 GARDEN STREET
ELIZABETH, NEW JERSEY
ELizabeth 2-9613

new Yarway Unit Tandem Valve for blow-off service up to 665 lbs. WSP ...provides proven Yarway Unit Tandem dependability for medium pressure installations. Streamlined, light in weight, easy to operate, tight sealing, with minimum maintenance.

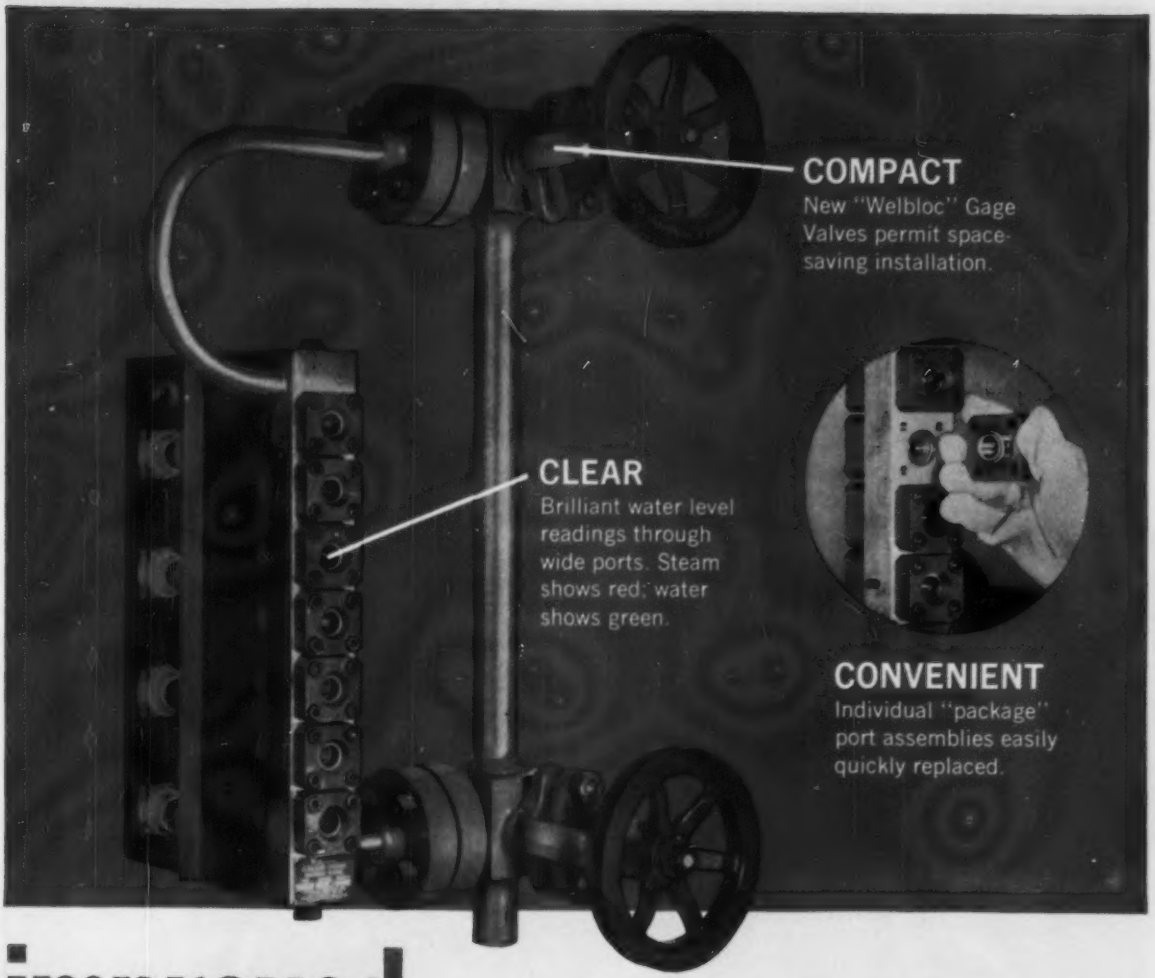
Ask for free Bulletin B-435, Supplement A

YARNALL-WARING COMPANY • 100 Mermaid Ave., Philadelphia 18, Pa.
BRANCH OFFICES IN PRINCIPAL CITIES

YARWAY
A MARK OF QUALITY IN STEAM ENGINEERING

TIGHT
Sealing valve is time-proven Yarway Seatless design.
TOUGH
Blowing valve features stellite-faced disc and integral stellite seat.
TRIM
Both valves, mounted together, permit more compact piping with reduced weight.

A FEW OF THE MANY SATISFIED USERS: U. S. Sugar Corp. • West Point Mfg. Co. • Hammermill Paper Co. • R. J. Reynolds Tobacco Co. • Pulp and Paper Co., Colombia, S. A. • Western Electric Co. • Cornell University


COMPACT
New "Welbloc" Gage Valves permit space-saving installation.
CLEAR
Brilliant water level readings through wide ports. Steam shows red; water shows green.
CONVENIENT
Individual "package" port assemblies easily quickly replaced.

improved Yarway Color-Port Gages for medium pressure boiler service to 1050 psi*—with new "Welbloc" Gage Valves—offer you reduced maintenance, increased operational time, brilliant red and green level readings.

*High pressure design for pressures to 3000 psi also available

Write for new Yarway Bulletin WG-1815

YARNALL-WARING COMPANY, 100 Mermaid Ave., Philadelphia 18, Pa.

BRANCH OFFICES IN PRINCIPAL CITIES

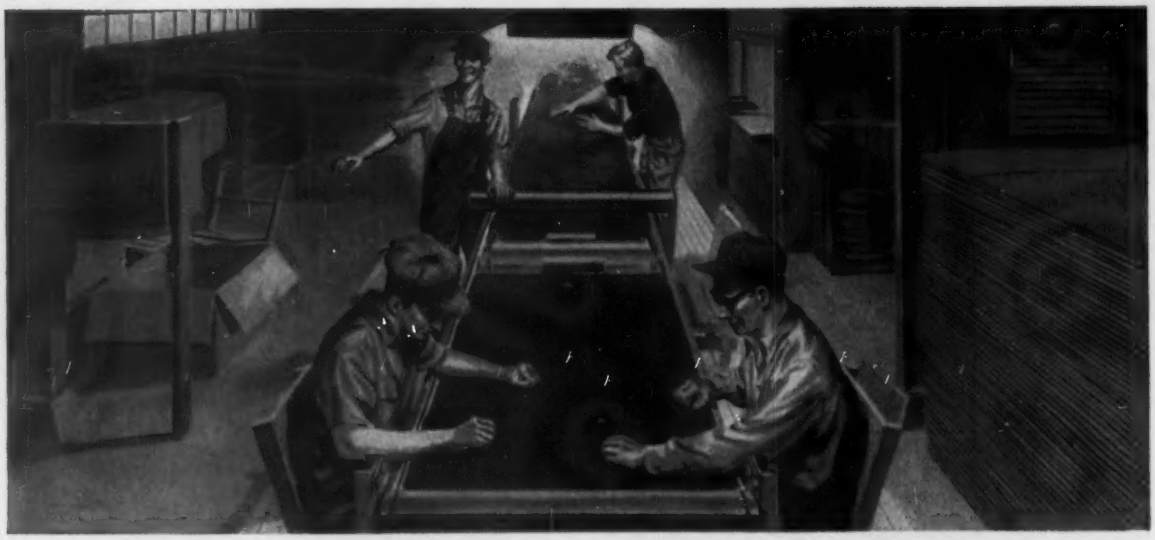
YARWAY

A MARK OF QUALITY IN STEAM ENGINEERING

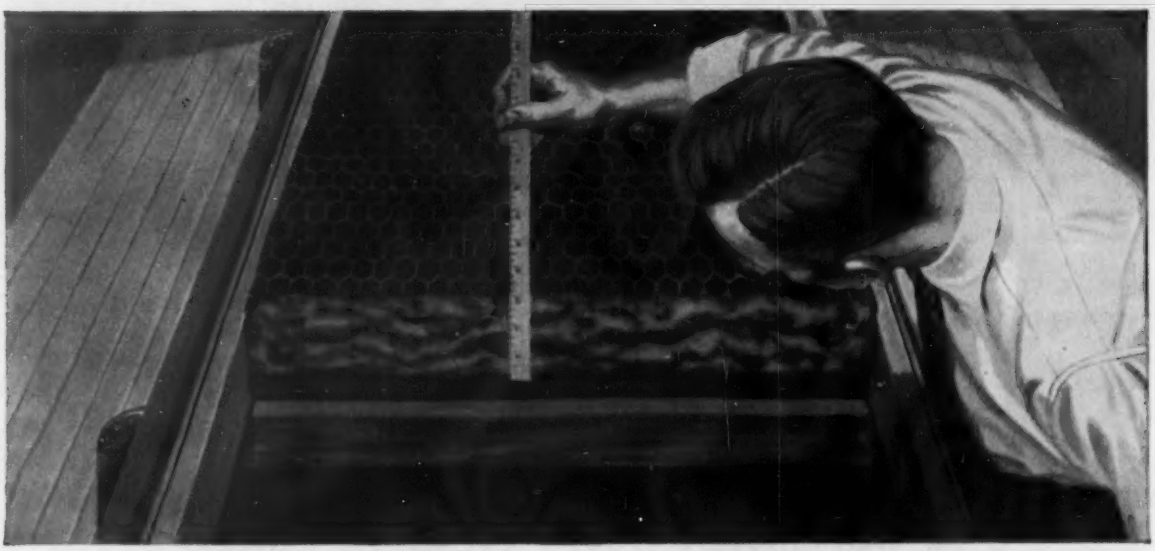
A FEW OF THE MANY SATISFIED USERS OF COLOR-PORT GAGES

Mead Corporation
Shell Oil Company
Allis Chalmers Company
Alan Wood Steel Company
California Oil Company
City of Vineland, N. J.
General Chemical Co.
University of Texas
Pittsburgh Plate Glass Co.
Youngstown Sheet & Tube Company
E. I. du Pont de Nemours & Co.
Scott Paper Company

For more facts circle 217 on Reader Service card, p. 119



FACTORY FABRICATED TO RIGID SPECIFICATIONS!

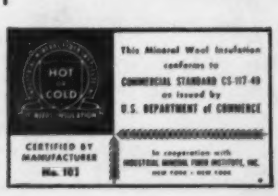


Don't risk efficiency with careless, made-on-the-job blankets.

- Copper bearing steel laths, bound by uniformly spaced soft-drawn galvanized tie wires, keep blankets firm but flexible.
- Eagle-Picher mineral wool evenly dispersed over entire insulating area of each blanket.
- Completely free of large voids usually found in field-made blankets where insulation is haphazardly packed in place.
- Smooth edges butted tightly together eliminate cracks and loose joints.
- Quickly applied to flat or slightly curved surfaces of any large equipment—or cut to fit irregular areas.
- Maximum thermal efficiency at temperatures as high as 1200 F.

Eagle-Picher produces a complete line of industrial insulations for all temperatures from below Zero to over 2000 F.

EAGLE-PICHER BLANKET INSULATION

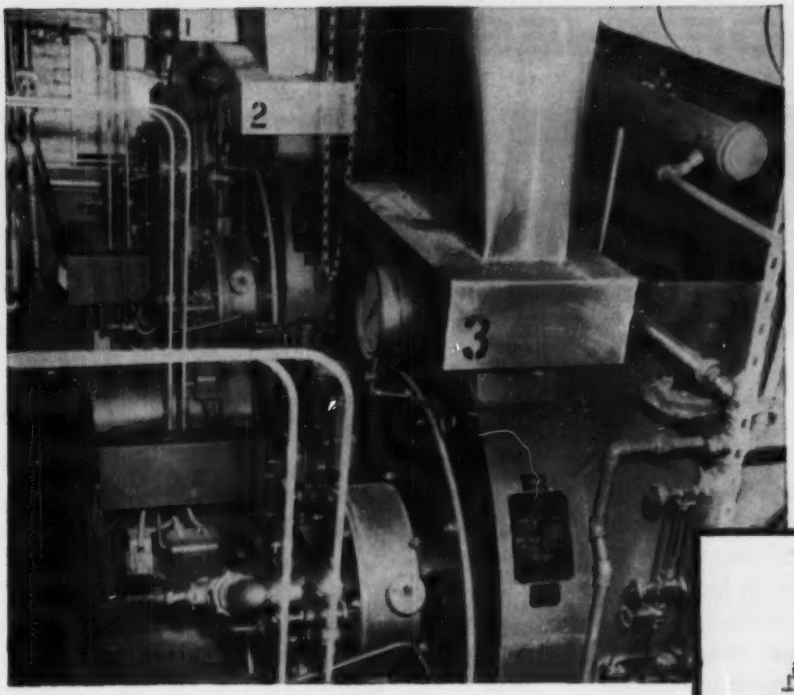


FREE SAMPLE!
Write today!

Since 1843
The Eagle-Picher Company
Dept. P-860
Cincinnati 1, Ohio

EAGLE EP PICHER

For more facts circle 218 on Reader Service card, p. 119

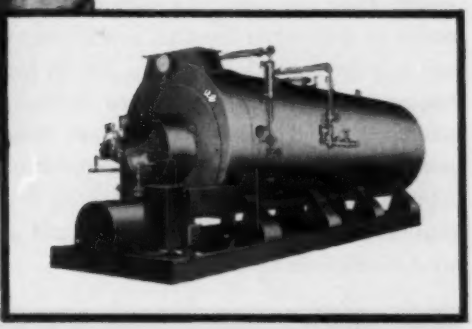


HERCULES-GALION PRODUCTS, Inc., Saves $15,000 Per Year!

Hercules-Galion Products, Inc., of Galion, Ohio, makers of dump truck bodies, ready-mix concrete truck equipment, and steel burial vaults, retired two old style boilers.

To improve heating efficiency, they installed three Cyclotherm 125 h.p. combination light oil/gas package steam generators. The total savings per year comes to $15,000.

As growing production or expanding plant facilities require more steam, Cyclotherms can be added when needed.



CYCLOTHERM

Steam capacity that grows with the plant!

When you recommend Cyclotherm Steam Generators you recommend a steam source that can be quickly and economically expanded to meet plant expansion. For Cyclotherm's wide range of capacities permits the addition of exactly as much new capacity as may be needed at any time. Will 518 lbs. of steam per hr. suit the requirements? That's what a 15 HP Cyclotherm produces. Or are 25,875 more steam lbs. per hour wanted? In that case, a 750 HP Cyclotherm fills the bill. And between these extremes there are sixteen intermediate sizes to choose from.

Compact Cyclotherms are also kind to boiler room space – the Cyclotherm is up to ⅓ smaller than the ordinary package boiler. Installation is easy—no costly stack, no excavation, no foundation. The Cyclotherm is shipped complete – ready to operate. Burner and boiler are built together to work together with *one* manufacturing responsibility back of the entire unit.

Cyclotherm's Cyclonic Combustion guarantees a minimum of 80% efficiency. Larger units operate at from 30% to 100% of rated capacity with no loss of efficiency. Smaller units operate on and off automatically according to load requirements. With simpler design and fewer parts, Cyclotherm reduces maintenance costs by from 30% to 50%. Cyclotherm's world-wide service organization gives prompt service on every call. For full information, write us today.

There are 18 Cyclotherm models, ranging from 15 HP to 750 HP. Burns oil and/or gas. The Cyclotherm meets all state requirements and is built in accordance with A.S.M.E. and National Board Standards and bears the label of Underwriters' Laboratories, Inc. Guaranteed against any defect in materials or workmanship. Cyclotherm also manufactures a complete line of Hot Water Generators in 10 capacities, from 670,000 BTU per hr. to 6,700,000 BTU per hr.

YEARS AHEAD IN STEAM & HOT WATER GENERATION

CYCLOTHERM®

STEAM AND HOT WATER GENERATORS

DIVISION OF CRANE CO., OSWEGO, N. Y.

Clip to Your Letterhead

Cyclotherm Division
of Crane Co.
67 E. First St., Oswego, N. Y.

Please send me your booklet *Cyclotherm Cyclonic Combustion*, also rotogravure copy of *Cyclotherm Sales Steam* with illustrations and descriptions of Cyclotherm installations.

For more facts circle 219 on Reader Service card, p. 119

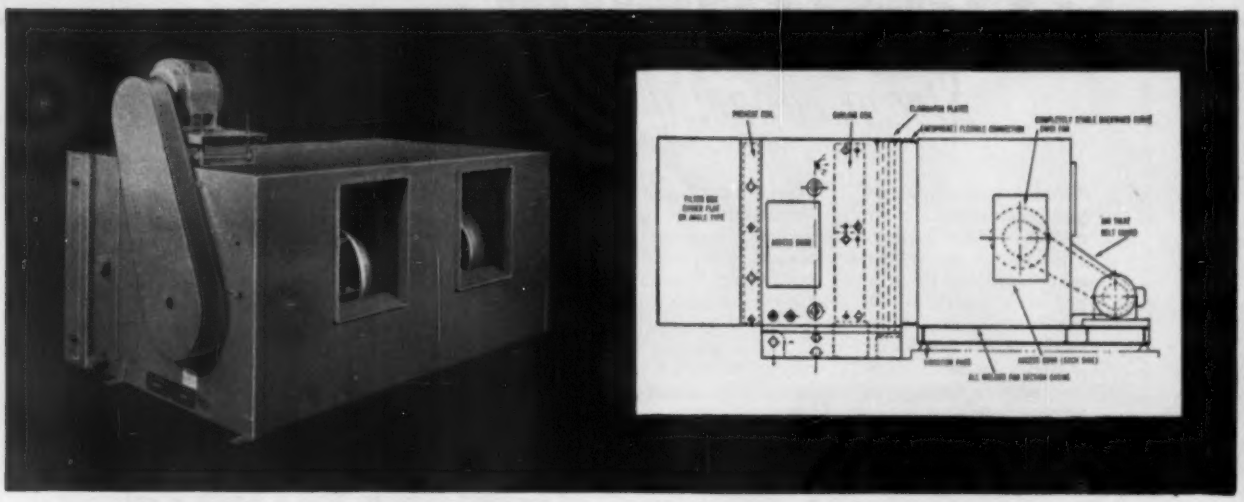
WHICH OF THESE

'BUFFALO'

BELONGS ON

Heating and Ventilating in efficient packages ready to install. These are basic fan sections of the same quality design as used in our finest air conditioning cabinets—and may be had with or without Aerofin heating coils, filter and mixing boxes, dampers and 'Buffalo' 45° or 90° stationary or adjustable outlet elbows. Units may be installed for vertical or horizontal operation. Cabinet support clips permit either floor mounting or ceiling suspension. For arrangements, capacities and dimensions, write for Bulletin UH-130.

Our new compact high-pressure unit (4" to 8" water gauge) not only permits a minimum-sized cabinet, ducts and grills; but minimizes the need for mechanical refrigeration during marginal weather. Sprayed-coil washer section provides high saturation efficiency. Here is a complete factory-fabricated package with air washing, humidifying and evaporative cooling in addition to standard central station air conditioning functions. Available with attached sound attenuator, if desired. Write for Bulletin AC-150.

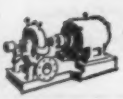


Your 'Buffalo' Engineering Representative will be happy to supply you with information

BUFFALO

BUFFALO,

Buffalo Pumps Division, Buffalo, New York



Buffalo Centrifugal Pumps to handle most liquids and slurries under a variety of conditions.

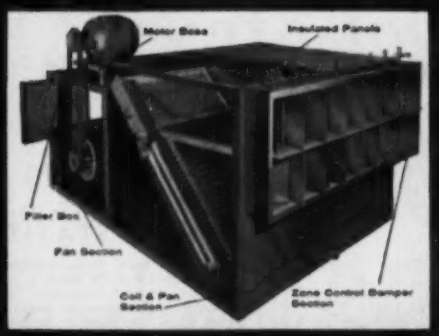
Squier machinery to process sugar cane, coffee and rice. Special processing machinery for chemicals.

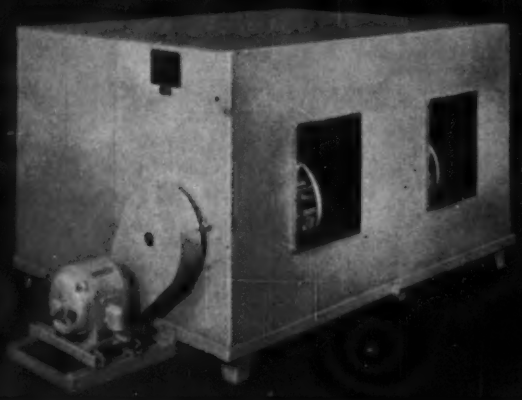
CABINETS

YOUR NEXT JOB?

Zone Control Air Conditioning At Its Finest. The same quality features of fan, housing, coil and casing built into Type PC Cabinets are present in 'Buffalo' Type PCB Zone Control Cabinets. The rugged tubular frame—easily assembled panels—handy access doors and outside bearings provide easy servicing. The quality Aerofin 45° pitched coils provide low headroom. And an exclusive 'Buffalo' feature is individual factory-sizing of damper zones for accurate proportioning of air flow. Write for Bulletin AC-220.

For your largest central station air conditioning jobs 'Buffalo' PC Cabinets offer easy installation and minimum service. Fans are quality 'Buffalo' double-width, double-inlet type of lightweight, non-sparking aluminum. Oversize hollow shafts for vibrationless operation. Backward curved fan blades, plus streamlined housings, provide completely stable performance and limiting horsepower characteristic—no need to select an oversize motor. A heavy welded steel plate drip pan supports all functional elements. Casings are removable heavy-gauge panel, galvanized and factory primed. Write for Bulletin AC-121 for arrangements and sizes to meet any requirements.





and suggestions on equipment for any air conditioning application you may require.

FORGE COMPANY

NEW YORK

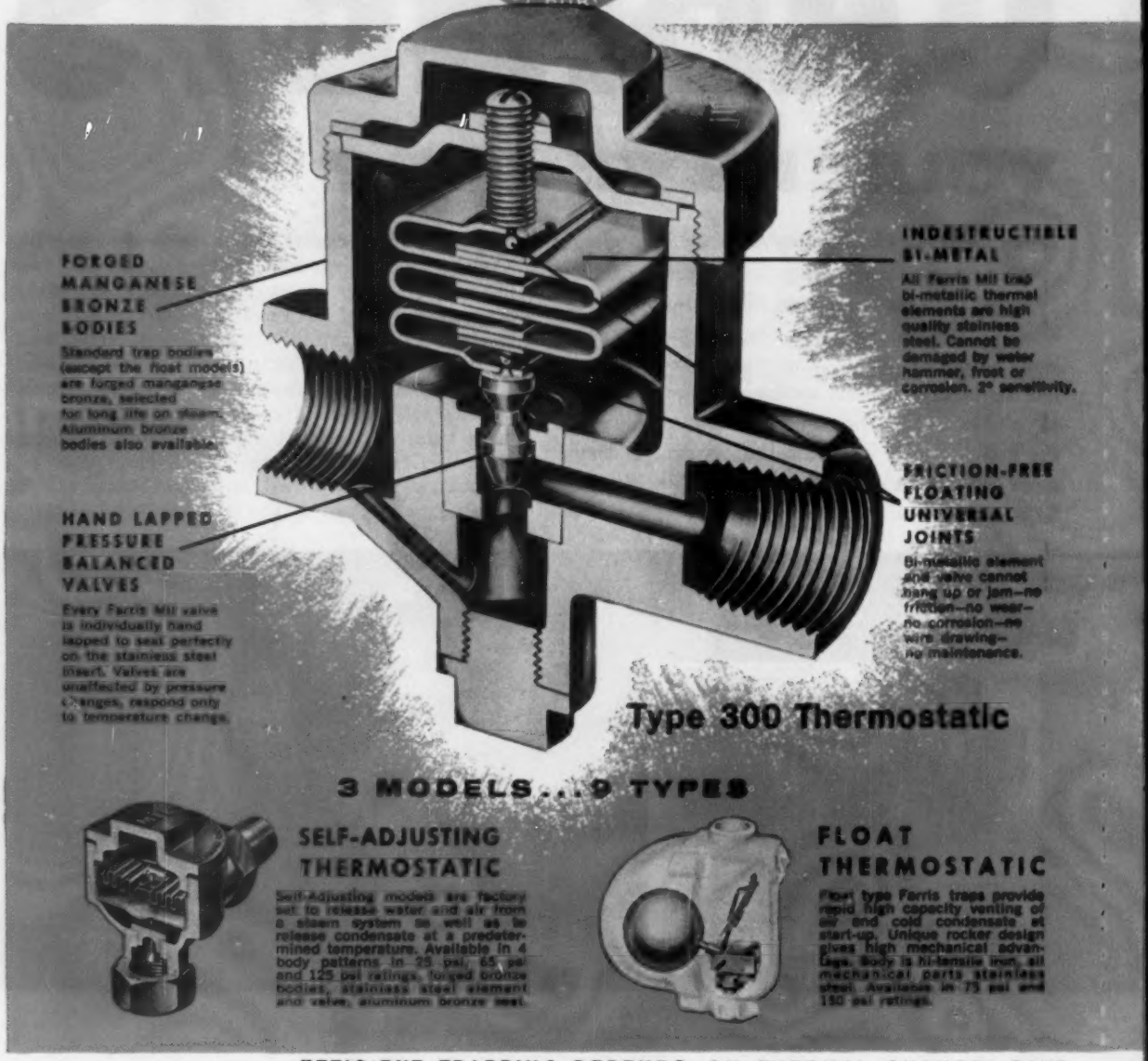
Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

Buffalo air handling equipment to move, heat, cool, dehumidify and clean air and other gases.

Buffalo Machine Tools to drill, punch, shear, bend, slit, notch and cope for production or plant maintenance.

For more facts circle 220 on Reader Service card, p. 119

ONLY Farris MIL


FORGED MANGANESE BRONZE BODIES
Standard trap bodies (except the float models) are forged manganese bronze, selected for long life on steam. Aluminum bronze bodies also available.
HAND LAPPED PRESSURE BALANCED VALVES
Every Farris Mil valve is individually hand lapped to seat perfectly on the stainless steel insert. Valves are unaffected by pressure changes, respond only to temperature change.
INDESTRUCTIBLE BI-METAL
All Farris Mil trap bi-metallic thermal elements are high quality stainless steel. Cannot be damaged by water hammer, frost or corrosion. 2° sensitivity.
FRICTION-FREE FLOATING UNIVERSAL JOINTS
Bi-metallic element and valve cannot hang up or jam—no friction—no wear—no corrosion—no wire drawing—no maintenance.
Type 300 Thermostatic

3 MODELS...9 TYPES

SELF-ADJUSTING THERMOSTATIC

Self-Adjusting models are factory set to release water and air from a steam system as well as to release condensate at a predetermined temperature. Available in 4 body patterns in 25 psi, 65 psi and 125 psi ratings, forged bronze bodies, stainless steel element and valve, aluminum bronze seat.

FLOAT THERMOSTATIC

Float type Farris traps provide rapid high capacity venting of air and cold condensate at start-up. Unique rocker design gives high mechanical advantage. Body is hi-tensile iron, all mechanical parts stainless steel. Available in 75 psi and 150 psi ratings.

EFFICIENT TRAPPING DEPENDS ON THERMAL CHANGE! SAVE WITH MIL THERMOSTATIC TRAPS FOR ALL PLANT-WIDE SERVICE

SEND FOR NEW CATALOG

Free 8 page Farris Mil trap catalog #FE-310 gives complete dimensional data, performance information, and capacities for all 9 types.

Manufactured under patents, patents pending and licenses of Midland Industries Ltd., the largest producer of thermostatic steam traps in Europe.

Farris ENGINEERING CORP.

MIL DIVISION

627 COMMERCIAL AVENUE • PALISADES PARK, N. J.

AFFILIATES:
Farris Flexible Valve Corp. • Farris Engineering Ltd., London, England • Farris Universal Machine Corp. • Farris Combustion Controls Corp. • Midland Industries Ltd., Wolverhampton, England

STEAM TRAPS

are indestructible ■ will not wire draw ■ will not freeze up ■ cannot be damaged by water hammer ■ do not need a cooling leg ■ cannot corrode ■ operate instantaneously ■ are pressure balanced ■ have full floating, friction free, self aligning, stainless steel valves ■ cost less ■ are guaranteed two years

OVER A MILLION IN USE! TRY US—SEND YOUR ORDER FOR ONE OR MORE TRAPS. YOUR MONEY BACK IF THEY DO NOT PERFORM AS STATED!

UNRETOUCHED ACTION PHOTOS PROVE SUPERIOR PERFORMANCE OF BUELL CYCLONES

an ordinary cyclone

THE BUELL CYCLONE
with Shave-Off

These are photographs of as true a test as can be made under laboratory conditions. Notice the difference in the dust patterns! In the Buell Cyclone, on the left, the dust at the top makes less than one revolution before it is trapped by the Shave-Off. It's then channeled down to the lower portion of the Cyclone, well below the clean gas outlet.

Why is the Buell Shave-Off so effective? Primarily because it harnesses the double-eddy current to convey the dust "fines" downward quickly, thereby promoting greatly increased efficiencies. In the ordinary cyclone, as shown on the right, these "fines" concentrate and recirculate at the top, causing erosion of the cyclone. To be collected, the fine dust must travel downward close to the clean gas outlet where much of it escapes. Buell Cyclones have made an impressive record in many years of trouble-free service. To see how their extra efficiency in the Shave-Off can pay off for you, send for our Cyclone Catalog #103. The Buell Engineering Co., Inc., 123 William Street, New York 38, New York. Northern Blower Division, 6428 Barberton Avenue, Cleveland, Ohio. (Subsidiary: Ambuco Ltd., London, England.)

buell Norblo

CYCLONES • ELECTRIC PRECIPITATORS • BAG COLLECTORS • COMBINATION SYSTEMS • FANS • CLASSIFIERS

For more facts circle 222 on Reader Service card, p. 119

circle 223 on Reader Service card, p. 119 ➤

General Electric turbine design engineers: J. E. Downs and H. Hegetschweiler

NOW BEING BUILT
FOR DUKE POWER COMPANY

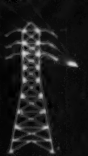
First Pre-Engineered Cross-Compound, Double-Flow, Reheat Steam Turbine, With New Compact, Two-Casing Design

One of General Electric's new pre-engineered steam turbines can be adapted to fit your specific station and load requirements. Among the various pre-engineered turbines already being built is the 3600-/1800-rpm, cross-compound, double-flow, reheat steam turbine. The first installation of this design will be at the Allen plant of Duke Power Company.

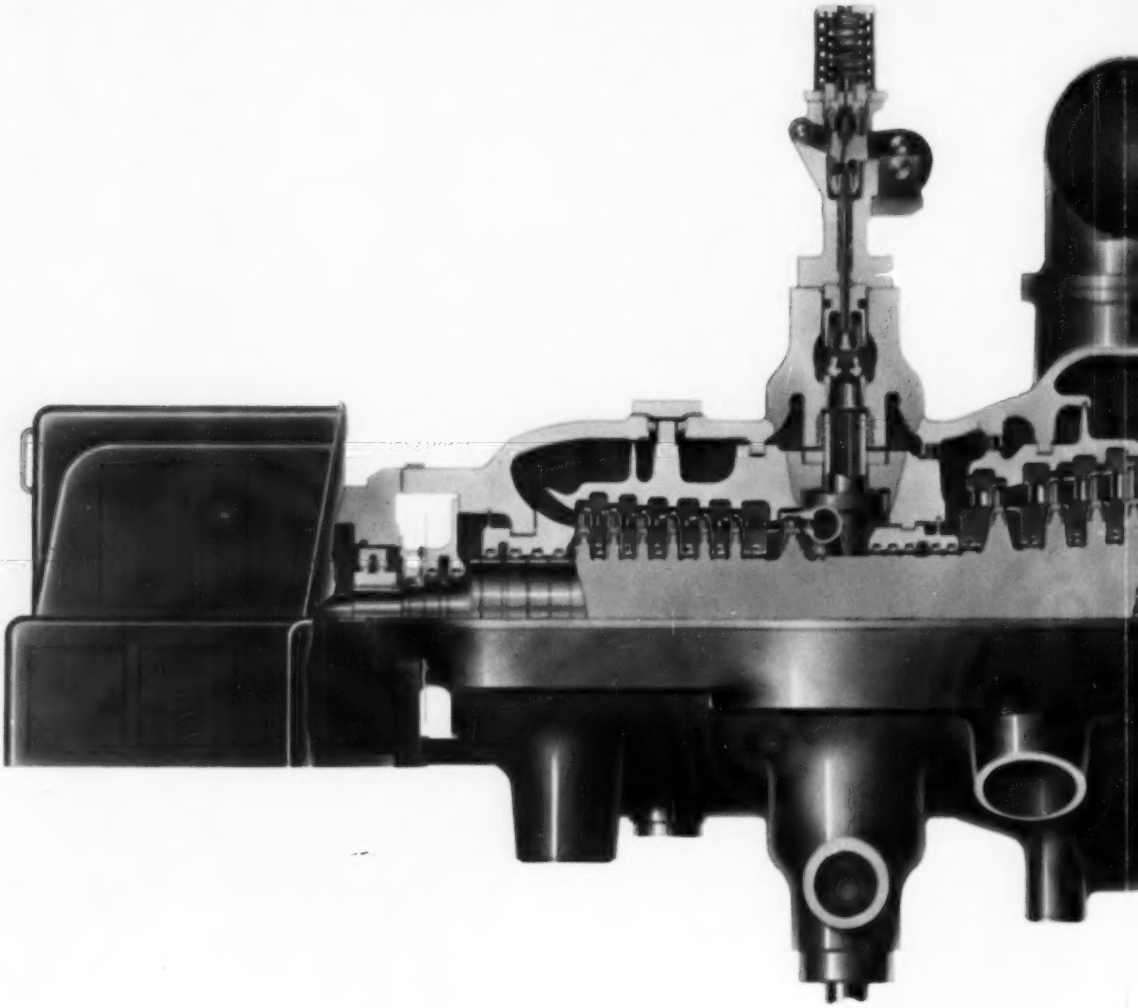
This compact turbine, featuring an extremely simplified design—with only two casings—is now available in ratings up to 400,000 kw. The new design retains the inherent qualities of General Electric large steam turbine-generators and also considerably lowers installation and maintenance costs over previous similar designs.

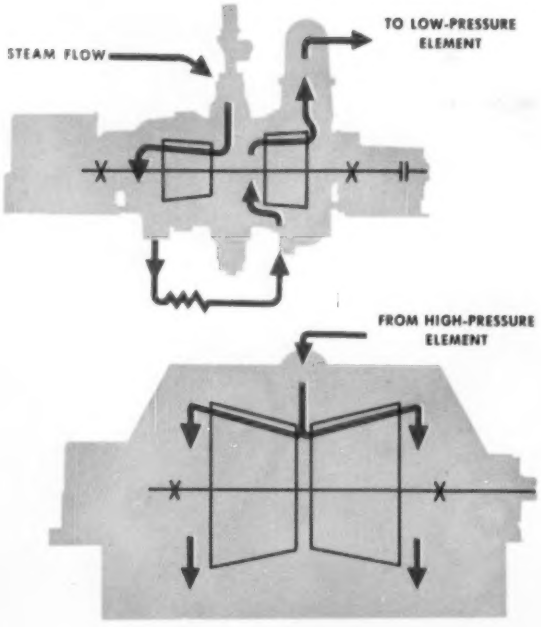
You can take advantage of these savings by using General Electric pre-engineered large steam turbine-generators. For more information, contact your G-E Apparatus Sales Office. General Electric Company, Schenectady, New York. 244-82

GENERAL ELECTRIC

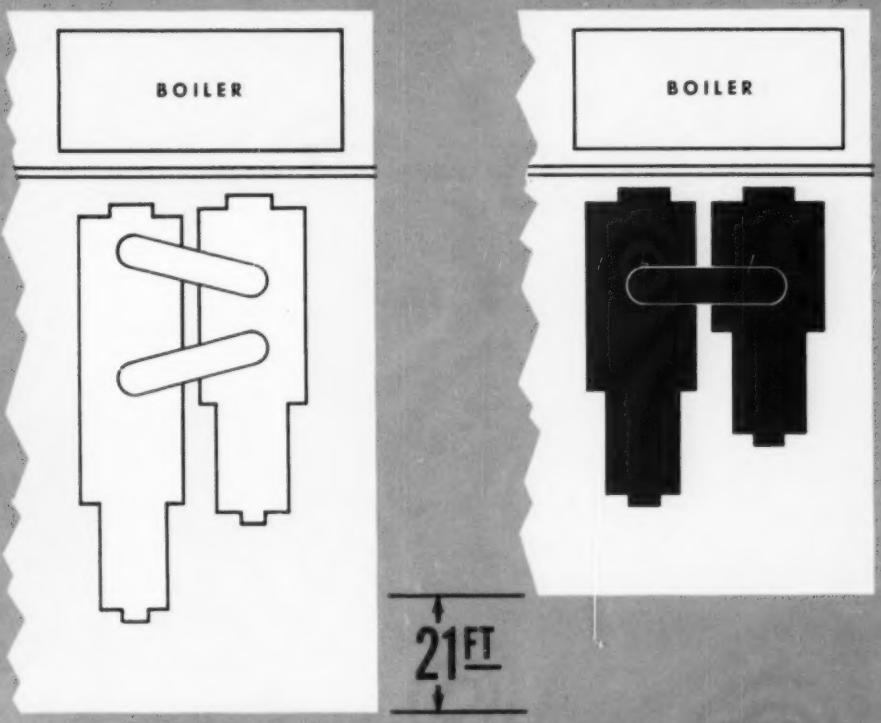


Profitable Power from General Electric Turbine-Generators




STEAM FLOW
TO LOW-PRESSURE ELEMENT
FROM HIGH-PRESSURE ELEMENT

LOWER INITIAL PLANT COSTS
WITH MORE COMPACT TURBINE-GENERATORS



Here's Why General Electric's New Cross-Compound, Double-Flow Steam Turbine Is The Most Compact Power-Generation Package

General Electric's new cross-compound, double-flow turbine can provide more kilowatts per square foot of floor space than any other turbine—with a resulting savings in installation costs. It is now actually possible to install 400,000 kilowatts of capacity in a space previously required for only 150,000 kilowatts. Because of the short, matched lengths of both shafts of this cross-compound turbine, the unit is particularly suited to plant expansions.

Installation cost savings can result from:

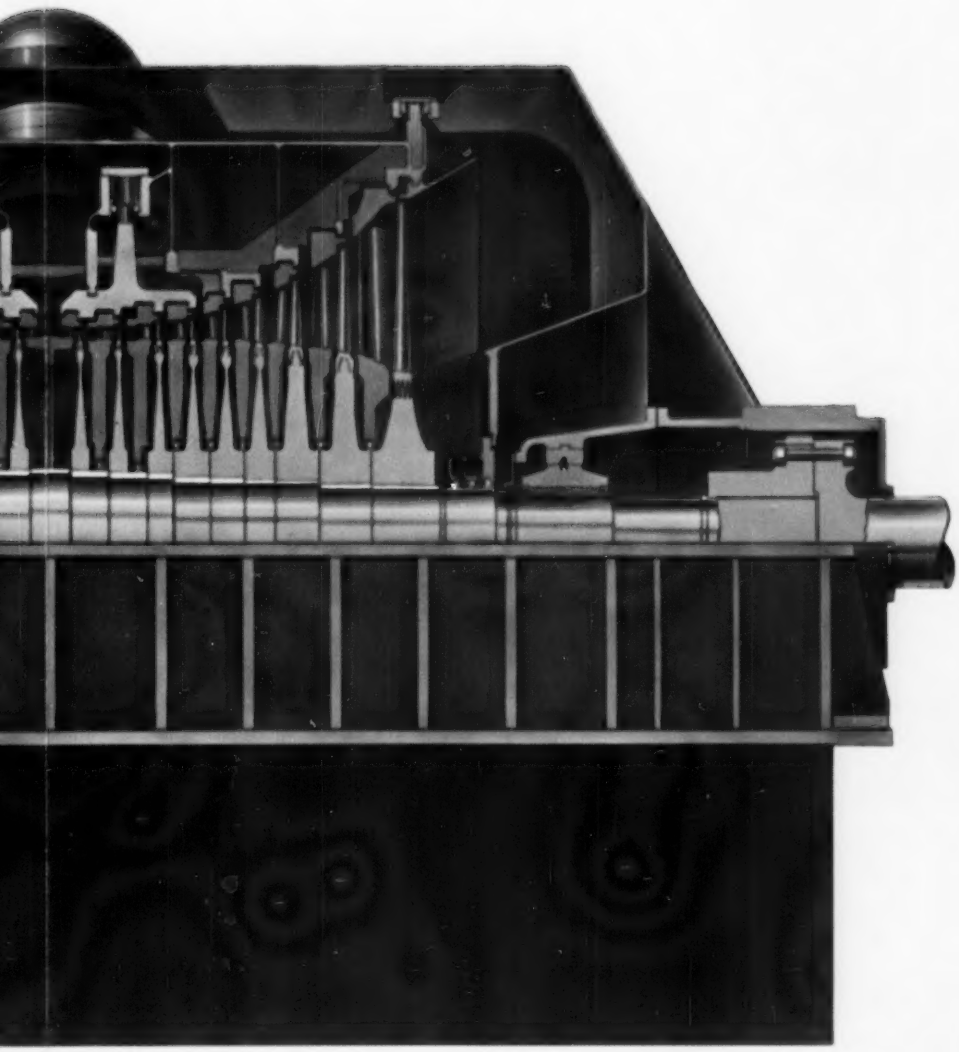
- reduced size of building expansion—for instance, short turbine may leave area for lay-down space
- utilization of existing crane span, and
- much smaller foundation requirements.

Inspection and maintenance time are reduced with this turbine because the whole unit is in only two casings—and the entire unit can be inspected and maintained by removing only two shells. This two-casing design is possible because General Electric's unique high-pressure/intermediate-pressure sections are combined into one casing. Also, two single-flow, low-pressure sections have been combined into a single span on the 1800-rpm shaft to eliminate a low-pressure element. This extreme simplicity means fewer shells, rotors, bearings, packings, and other parts—further reasons why the new General Electric cross-compound, double-flow turbine can save you installation and maintenance costs.

GENERAL ELECTRIC

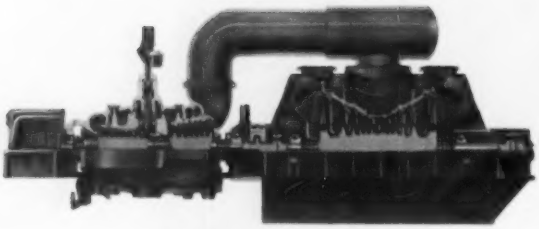
3600/1800-rpm, cross-compound,
double-flow, reheat steam turbine

GENERAL ELECTRIC

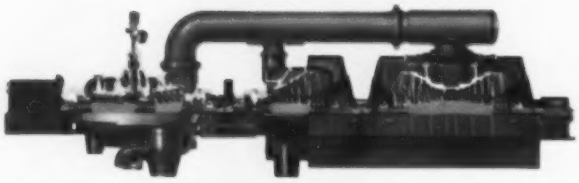


General Electric Pre-Engineered Steam Turbines

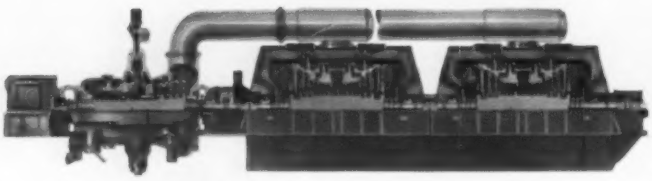
THAT CAN BE ADAPTED TO YOUR SPECIFIC LOAD REQUIREMENTS



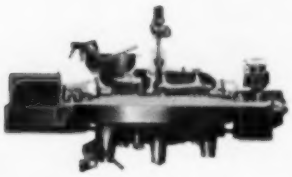
3600-rpm, tandem-compound, double-flow, reheat steam turbine

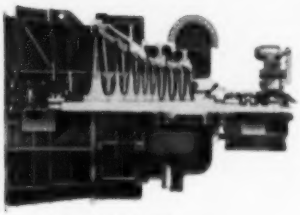


3600-rpm, tandem-compound, triple-flow, reheat steam turbine

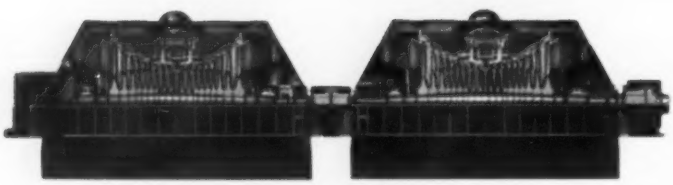


3600-rpm, tandem-compound, four-flow, reheat steam turbine

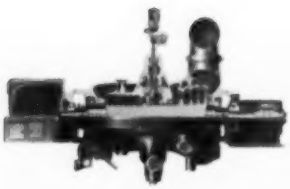


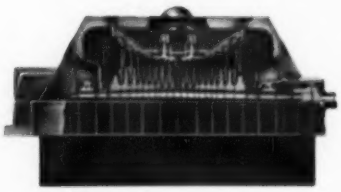


3600/1800-rpm, cross-compound, single-flow, reheat steam turbine



3600/1800-rpm, cross-compound, four-flow, reheat steam turbine





3600/1800-rpm, cross-compound, double-flow, reheat steam turbine

Progress Is Our Most Important Product

GENERAL ELECTRIC

This ion exchange unit deionizes boiler make-up water at Crown Zellerbach paper mill, Bogalusa, Louisiana.

AMBERLITE ion exchange resins condition water for Crown Zellerbach boilers

AMBERLITE ion exchange resins are used to remove silica and other ionized impurities from make-up water for high pressure boilers at the Bogalusa Mill of the Crown Zellerbach Corporation. The deionized water is needed for 900 psi boilers that supply steam for turbine-driven power generators. Effluent steam from the turbines is piped to paper-machine dryers.

To furnish the make-up, well water containing the high silica level of 30 ppm is fed to a two-bed deionizing system having 127 cubic feet of AMBERLITE IR-120 in the cation exchanger and 207 cubic feet of AMBERLITE IRA-400 in the anion exchange unit. Ion exchange treatment reduces silica content to 0.20 ppm and conductivity to 4 micromhos.

Flow rate of the water-conditioning system is 350 gallons per minute. Design specifications call for regeneration of the ion exchange beds after treatment of 505,000 gallons of water. However, the high capacity of the ion exchange resins has permitted the units to run consistently far beyond this limit, without exceeding the guaranteed silica content in the treated water.

Water conditioning is only one of the many fields in which AMBERLITE ion exchange resins have solved commercial problems. Others include recovery of costly metals from industrial wastes, removal of contaminants from numerous chemicals, and extraction of pharmaceuticals from reaction mixtures. Write for our booklets *Ion Exchange with the* AMBERLITE *Resins* and *If You Use Water* for more information on ion exchange applications.

AMBERLITE *is a trademark, Reg. U. S. Pat. Off. and in principal foreign countries.*

Chemicals for Industry

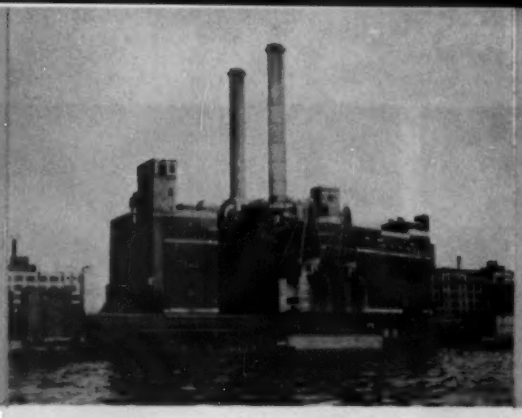
ROHM & HAAS COMPANY

THE RESINOUS PRODUCTS DIVISION

Washington Square, Philadelphia 5, Pa.

FIRST

East River Station. One of the three huge C-E boilers completed in 1929 for Consolidated Edison Company of New York was the world's first boiler to produce a million pounds of steam per hour. To mark the unit's completion, a luncheon for 90 persons was served inside its furnace.



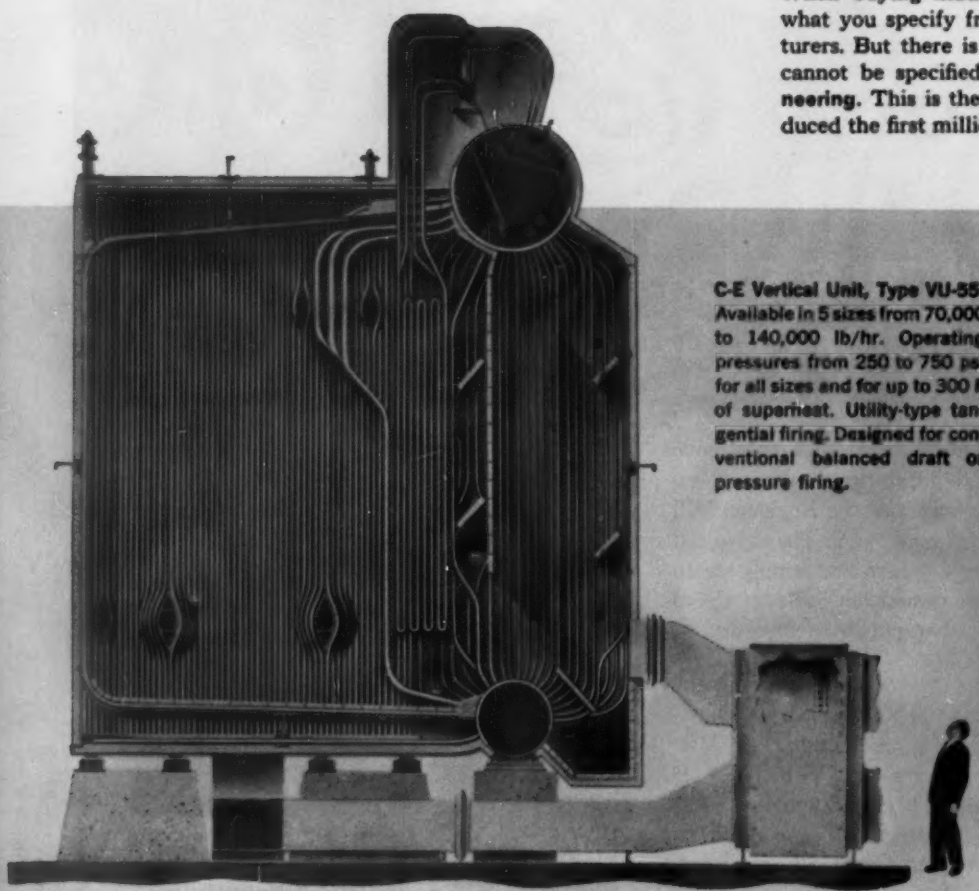
HIGHEST

Eddystone Station. World's highest-pressure utility boiler went into operation in 1959 at the Eddystone Station of Philadelphia Electric Company. This supercritical C-E unit serves a 325,000-kw turbine and is designed for an operating pressure of 5000 psi and temperature of 1200 F.

In C-E Industrial Boilers—

UTILITY-BOILER ENGINEERING

When buying industrial boilers, you can get what you specify from a number of manufacturers. But there is an intangible quality that cannot be specified: **C-E's utility-boiler engineering.** This is the engineering skill that produced the first million-pound-per-hour boiler in

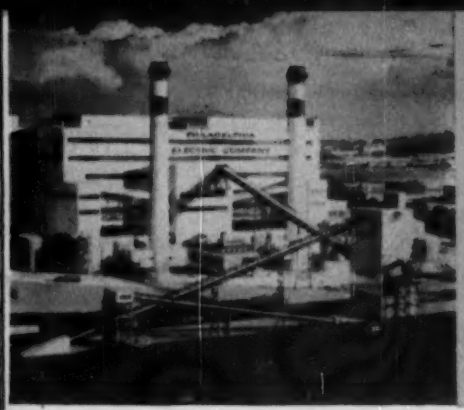


C-E Vertical Unit, Type VU-55. Available in 5 sizes from 70,000 to 140,000 lb/hr. Operating pressures from 250 to 750 psi for all sizes and for up to 300 F of superheat. Utility-type tangential firing. Designed for conventional balanced draft or pressure firing.

C-E Vertical Unit, Type VU-10. Available in 9 sizes from 10,000 to 60,000 lb/hr. Operating pressures to 475 psi, superheat to 150 F in 20,000-60,000 range. Efficient over a wide range of output. Coal, oil or gas-fired.

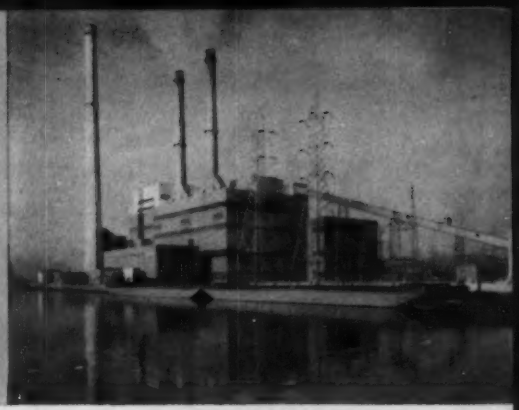
WRITE FOR CATALOGS

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS; PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE



LARGEST

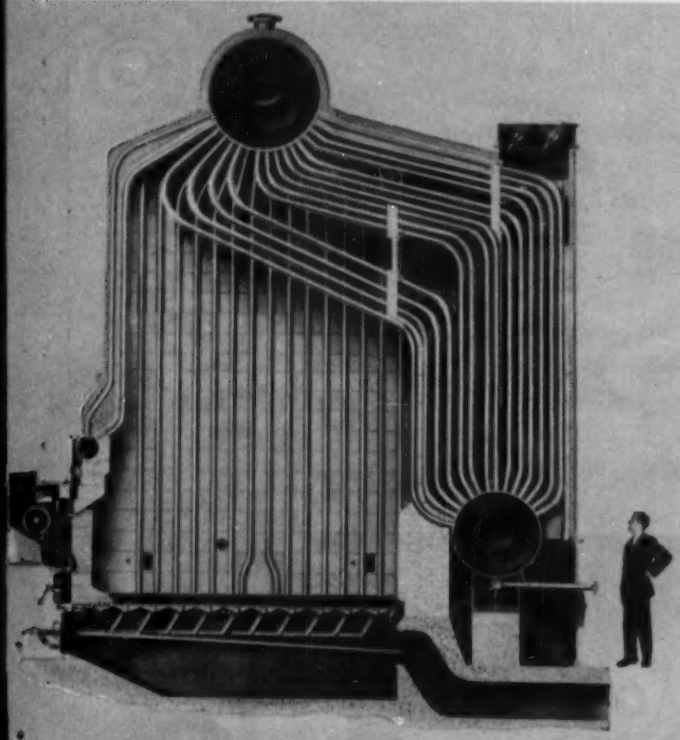
Will County Station. Work is in progress on an additional 510,000-kw C-E unit for the Will County Station of Commonwealth Edison Company, Chicago. The largest boiler ever ordered by an American utility company, the new 20-story structure will require over 450 carloads of material.



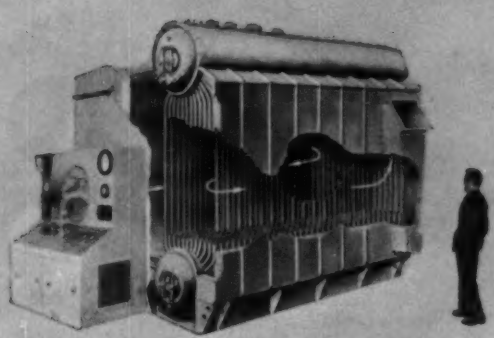
GIVES YOU EXTRA QUALITY

1929, the world's highest-pressure utility boiler in 1959, and is now at work on the largest boiler ever ordered by an American utility company.

Because C-E engineers are accustomed to the uncompromisingly high standards of the electric utilities, you can expect many extras when C-E builds an industrial boiler. These show up as refinements in design, uniformly high-quality materials, superior manufacturing techniques. For catalogs or other information, contact C-E headquarters or your nearby branch of C-E's nationwide sales and service organization.



C-E Package Boiler, Type VP. Available in two types and in a wide range of sizes from 4,000 to 90,000 lb/hr. Operating pressures to 700 psi, temperatures to 750 F. Reinforced, gas-tight, welded-steel casing. Ready to install on simple concrete foundation.



COMBUSTION C-E ENGINEERING

Combustion Engineering Building • 200 Madison Avenue, New York 16, N. Y.

Canada: Combustion Engineering-Superheater Ltd.

C-20

Leslie's *Inherently Stable* Design proves

PRESSURE CONTROLLERS *CAN* BE UNCOMPLICATED

If you're tired of babying cranky pressure controllers just to get satisfactory performance from them, here's the news you've been looking for. Now there's a simplified pressure pilot for the man who's ready to make a break with outmoded specs . . . who looks beyond traditional controller concepts of flapper nozzles, linkages, bourdon tubes, tiny ports and reset mechanisms to obtain narrow range pressure control with stability.

Leslie Pressure Pilots are short-lag factor pressure controllers, with inherent stability, that produce a speed of response proportional to the deviation from set point. The pilot maintains corrective action until the set point is restored; high loading and unloading capacity insures ability to handle large load changes.

There's no hocus-pocus to it—a simple diaphragm-stem assembly construction plus imaginative engineering does the trick. The result is a completely different controller—a husky, even-tempered pilot that maintains unattended control for years, even after high impact shock.

For sizing and capacity data on pressure control pilots, write for Bulletin or contact your Leslie representative. He's listed under 'Valves' or 'Regulators' in the Yellow Pages.

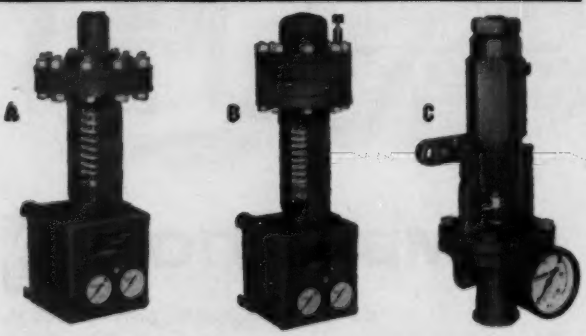
LESLIE

Leslie Co., 701C Grant Ave., Lyndhurst, New Jersey

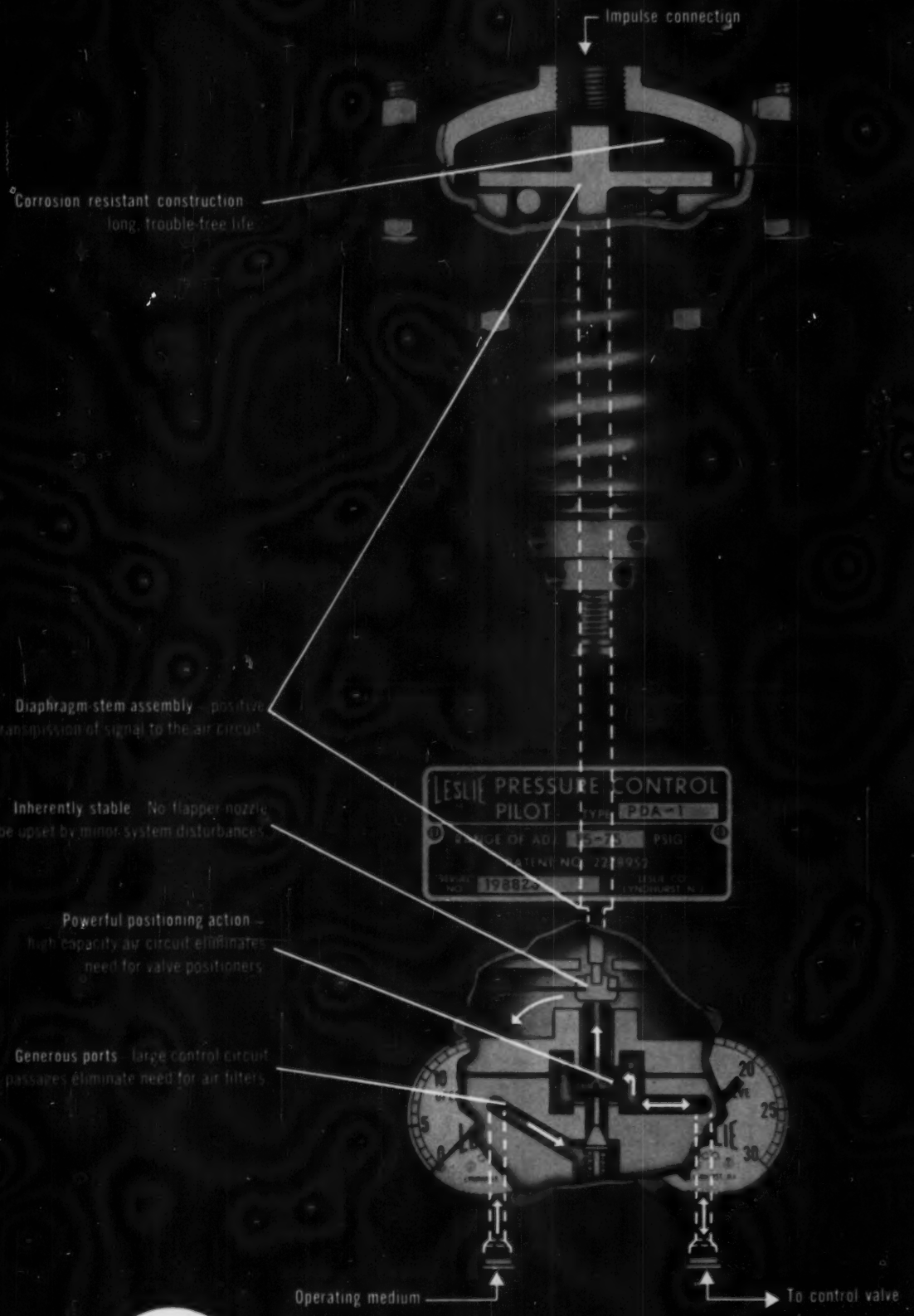
A Differential Pressure Pilots for maintaining a set differential between two pressures.

B Ratio Control Pilots with adjustable rate action combine a controlled pressure input signal and a pneumatic reference signal to provide a single output signal to final control elements.

C Fixed, Proportional Band Control Pilots for systems where control-loop lags and noise call for faster loading and unloading with stability.

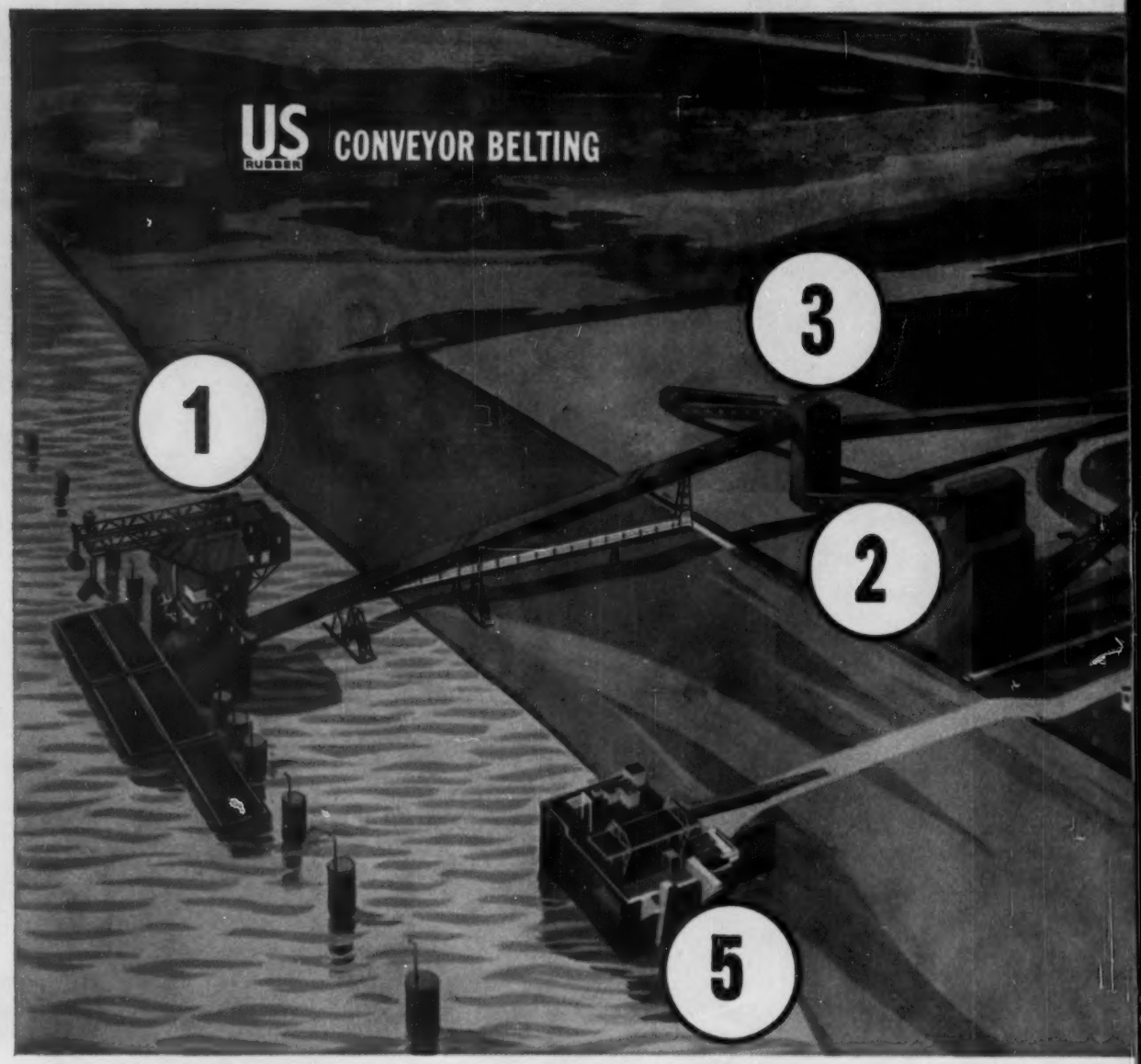


For more facts circle 226 on Reader Service card, p. 119



TRADE LESLIE MARK

REGULATORS and CONTROLLERS



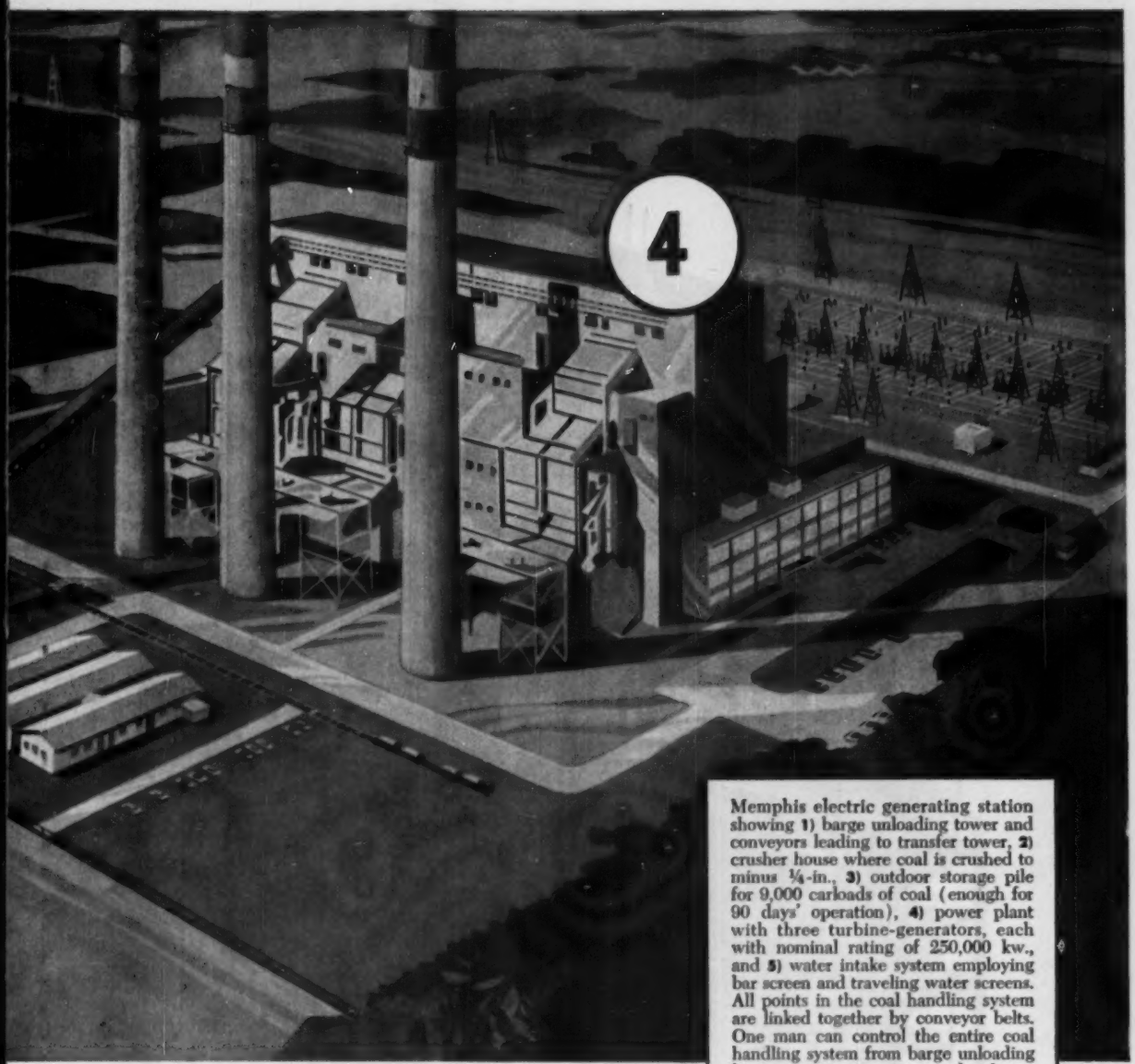
2,200 TONS OF COAL PER HOUR...all

The City of Memphis (Light, Gas & Water Division) operates the largest single steam power plant built to date for a municipality.

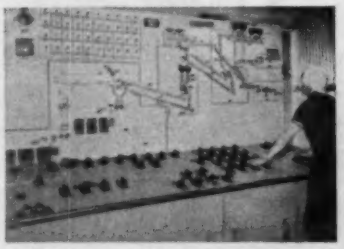
Link-Belt Company built and installed the mechanical conveyor system that conveys coal *from barge to transfer house, from transfer house to storage and from transfer house to crusher to bunkers.* U.S. Rubber constructed and furnished all belts conveying coal from transfer tower to the main power plant. Six conveyors in all are equipped with U.S. Conveyor Belts, including two 48"-wide U.S. Giant® Belts.

This extensive system is all controlled by one man operating the control panel in the transfer house.

The troughability and the training of the U.S. Rubber Belts result in efficient, economical operation, long life and freedom from maintenance. "U.S." Belts have long been noted for having these qualities. The inclusion of "U.S." Belts for this massive power plant is just one more unequalled instance that has made



Memphis electric generating station showing **1)** barge unloading tower and conveyors leading to transfer tower, **2)** crusher house where coal is crushed to minus ¼-in., **3)** outdoor storage pile for 9,000 carloads of coal (enough for 90 days' operation), **4)** power plant with three turbine-generators, each with nominal rating of 250,000 kw., and **5)** water intake system employing bar screen and traveling water screens. All points in the coal handling system are linked together by conveyor belts. One man can control the entire coal handling system from barge unloading hoppers to storage or to crusher house and bunkers. Lights and schematic diagram show portion of system in operation at any time.



controlled by one man

U.S. Rubber the foremost authority in the design, manufacture and installation of conveyor belts.

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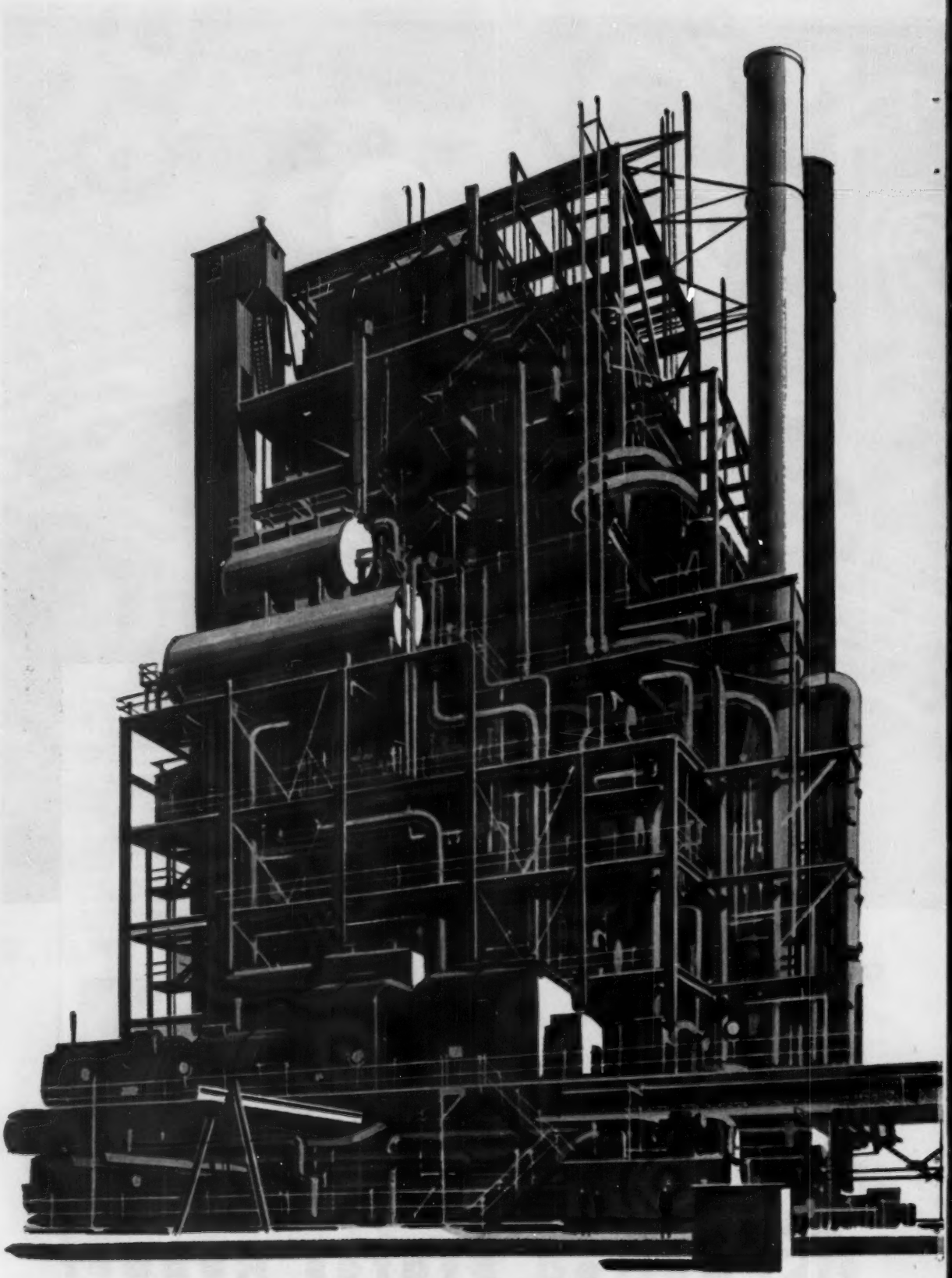
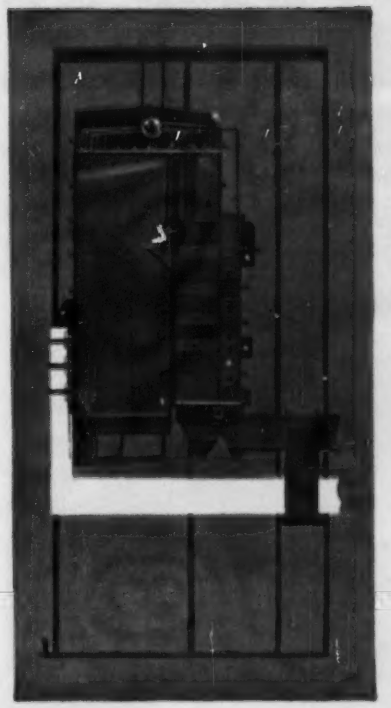


POWER PLANT PRODUCTS HEAT ENGINEERED BY FOSTER WHEELER:

Central Station and Industrial Steam Generators • Steam Condensers and Pumps • Pulverized Fuel Systems • Feedwater Heaters • Packaged Steam Generators • Cooling Towers • Nuclear Components

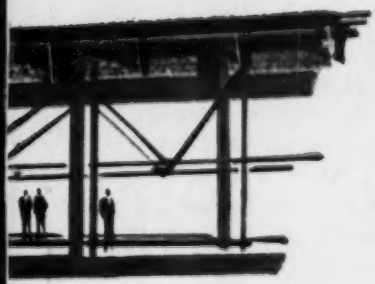


A word about steam generators

In this age of miracles some forthright words have been mislaid.

One is *thoroughness.*

Thoroughness is as much a product of our company as steam generators. By *thoroughness* we mean "careful attention to detail"—not some of the time but all of the time.



What does this mean to you? It means you save money on operations, keep your maintenance staff to a safe minimum, and prevent costly power interruptions.

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FOSTER WHEELER

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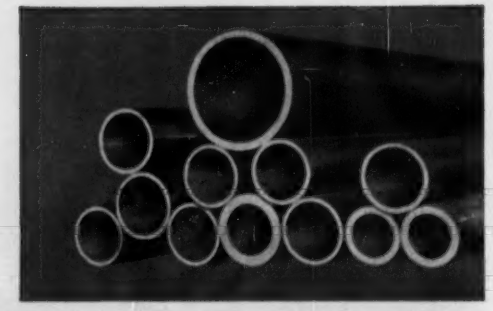
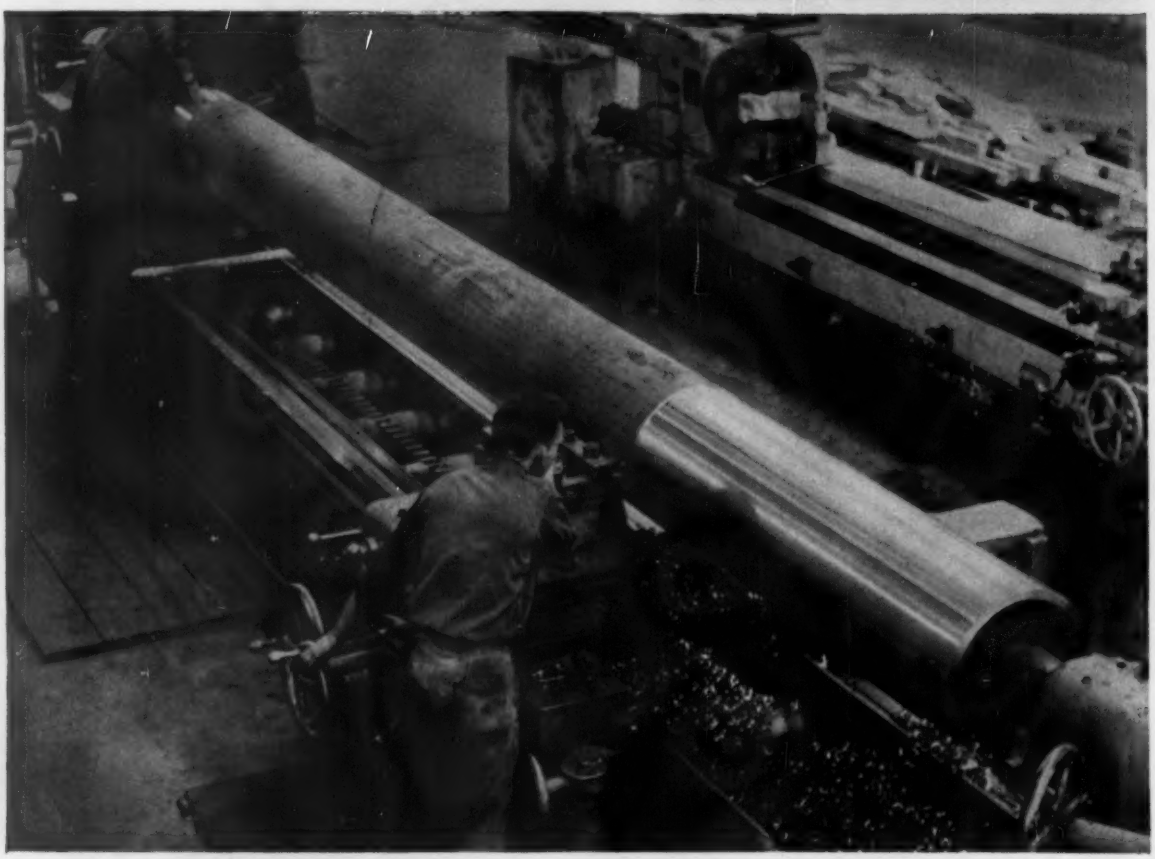
WHAT DO YOU LOOK FOR IN FORGED HEAVY WALL PIPE?





CLOSENESS TO DESIGN REQUIREMENTS?

Then call B&W. For B&W produces a range of sizes and alloys that meets your optimum design needs. Your special requirements can be promptly met with Forged Heavy Wall Pipe produced in special shapes or with special end preparation such as end closures, reduced diameter, Van Stone flanges.

And when it comes to quality, B&W gives you even more. From the initial electric furnace melting of the specified analysis through final inspection, B&W Forged Heavy Wall Pipe is put through a battery of quality control tests, including ultrasonic, that cost you not one penny extra. Write for the details. They're in Bulletin S-16. The Babcock & Wilcox Company, Boiler Division, Barberton, Ohio.

S-485-HF

B&W

THE BABCOCK & WILCOX COMPANY

BOILER DIVISION

For more facts circle 229 on Reader Service card, p. 119

circle 230 on Reader Service card, p. 119 ➤

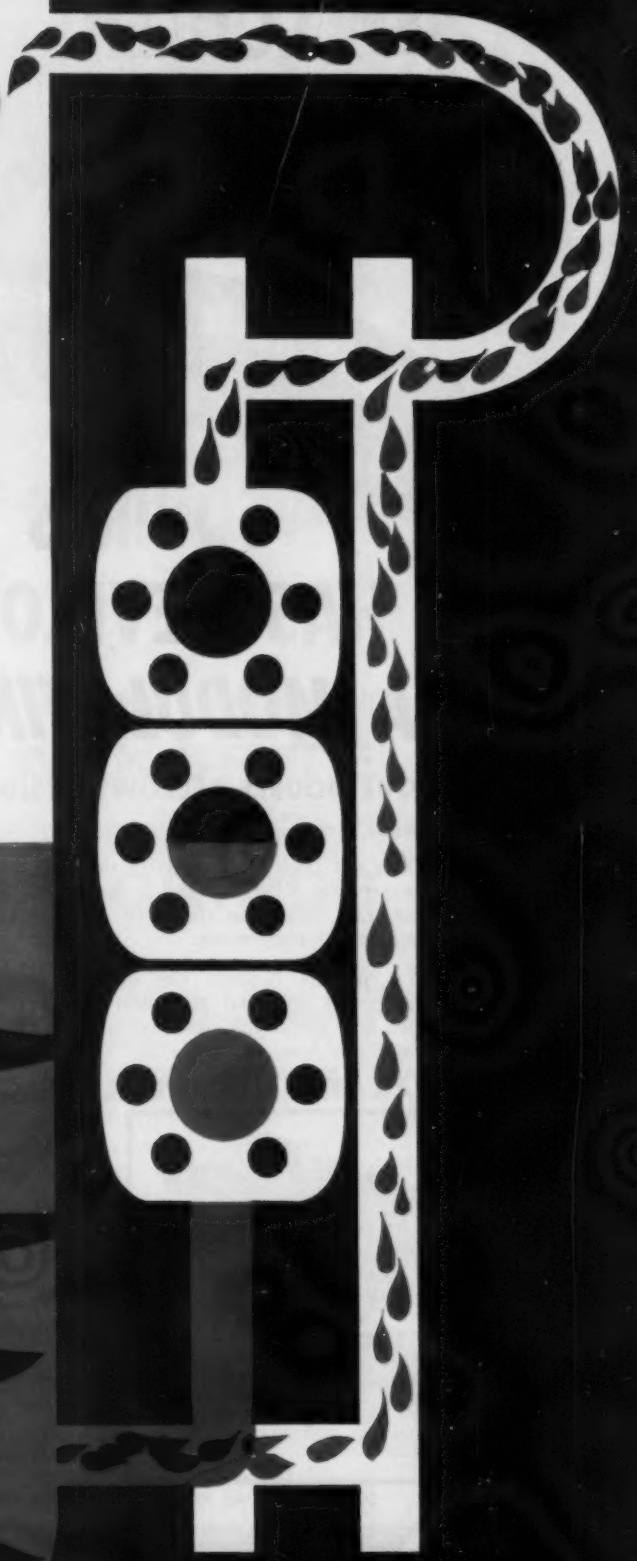
CONDENSATE BY-PASS . . .
DIRECT ROUTE TO IMPROVED WATER LEVEL INDICATION

Unmistakable water level readings are assured with Diamond's MP-3000 Multi-Port Bi-Color Gauge, equipped with condensate by-pass. A major reason for such performance is the unique and exclusive by-pass which traps any condensate before it reaches the port channel. The absence of condensate in the port channel assures a distinct bi-color image — red for steam, green for water. Regardless of operating pressure, there's a Diamond Gauge to provide accurate water level readings. Write for complete information or contact your local Diamond representative.

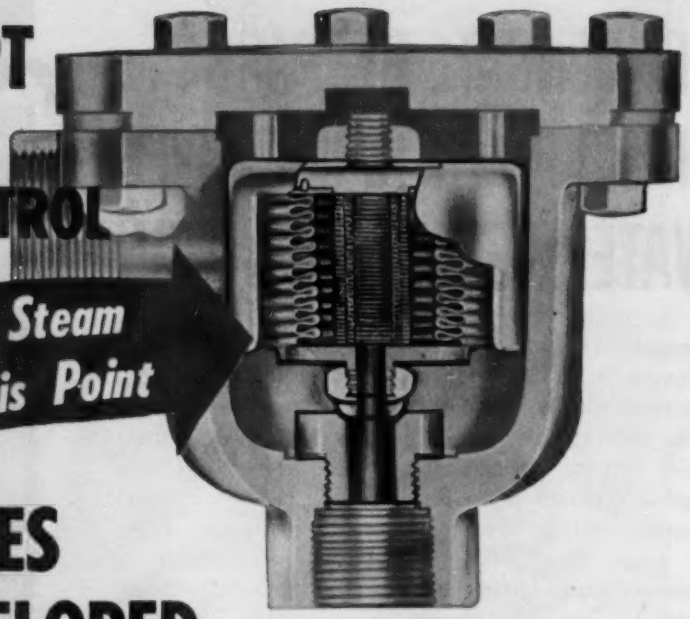
Diamond Power Specialty Corporation, Lancaster, Ohio

Diamond Specialty Limited • Windsor, Ontario

Diamond



A NEW CONCEPT IN CONDENSATE CONTROL



SQUIRES CLASS TM TRAP *

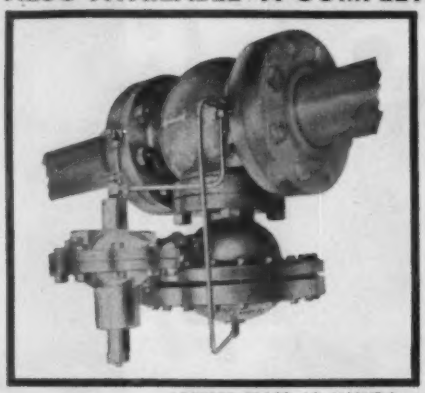
SQUIRES HAS DEVELOPED A *MODULATING* STEAM TRAP

A UNIQUE DOUBLE BELLOWS DESIGN BALANCES FORCE ACROSS THE SEAT

Which results in a trap that:

1) Does not cycle; it modulates open to the degree of condensate load in and ahead of the trap, closes on complete removal of condensate and/or air.
2) Has infinite bellows life due to small movement required to modulate, therefore is a minor maintenance and replacement problem.
3) Unusually large capacity because of balanced seat, i.e., 1¼" Class TMD has a ⅜" dia. orifice for all pressure and will handle condensate up to 35,000 lb./hr. modulated flow.
4) Operates only on presence (or absence) of latent heat, positively closes with no stream loss due to cycling.

ALSO AVAILABLE–A COMPLETELY FACTORY PREFABRICATED REGULATOR STATION



SQUIRES CLASS AD VALVE *

The Squires Class AD Valve provides:

1) Ease of installation, furnished completely piped within the flanges; no field pipe connections necessary.
2) Accurate control, designed to react to infinitesimal downstream pressure variations.
3) Wide range, one step reductions 600 psi to ounces or intermediate pressures.
4) Universal–the same valve can be used on steam, water, gas, air, and most fluid applications.

Write for complete information on the Class TM Trap and AD Valve described briefly above, other complete pressure, temperature, and level controls.

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THE C. E. SQUIRES COMPANY

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STYLE 804
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Asbestos graphite
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Temperatures to 800° F.

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Carbonite plastic core
Temperatures to 1000° F.

STYLE 807
NON-GRAPHITED
Monel-inserted asbestos over
Carbonite plastic core
Temperatures to 1000° F.

STYLE 809
GRAPHITE COATED
Inconel-inserted asbestos over
Carbonite plastic core
Temperatures to 1250° F.

STYLE 810
NON-GRAPHITED
Inconel-inserted asbestos over
Carbonite plastic core
Temperatures to 1250° F.

Look at the specs...and you will select

ANKORITE

High Pressure, High Temperature

PACKINGS

The Anchor Packing Company—with more than 50 years experience in the mechanical packing industry—specializes in *designing the packing for the application.* That is one reason why Anchor packings are always efficient, more effective and longer lasting.

Here's an example: Displayed in cross section are five ring and coil packings, all specially fabricated to give long service in high pressure, high temperature applications. Styles 806, 807, 809 and 810 are ideal in valve stems and expansion joints for superheated steam, hot gases and hot oils. Style 804 stays soft against high pressures and temperatures . . . is unsurpassed in control valves, throttle valves, autoclaves and similar services.

If you have a packing problem, see your local Anchor Representative. He will gladly assist you. Or, contact the Anchor General Office. Write for our new catalog.

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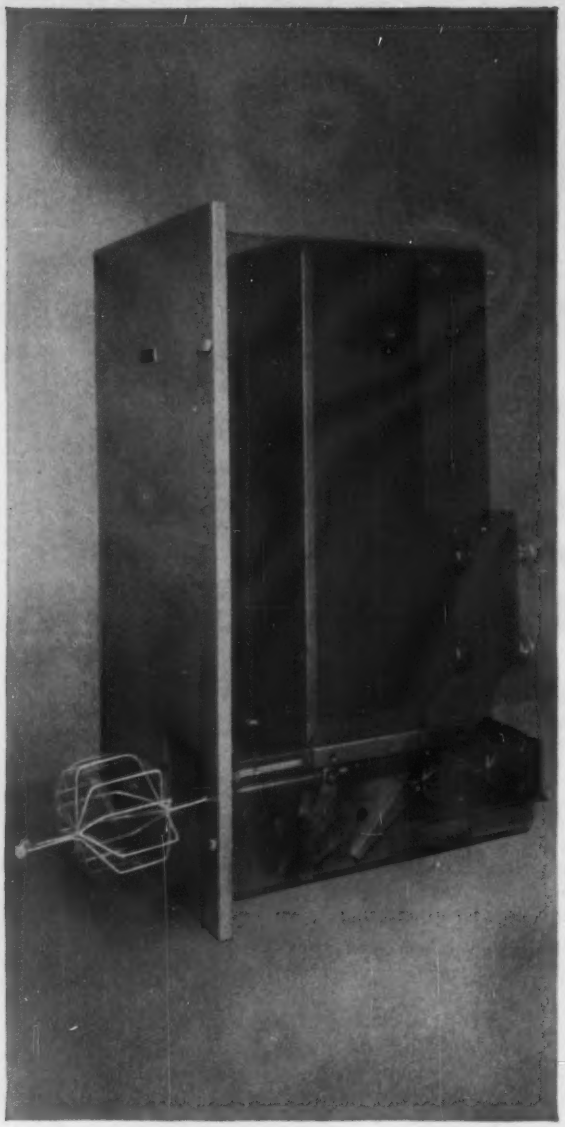
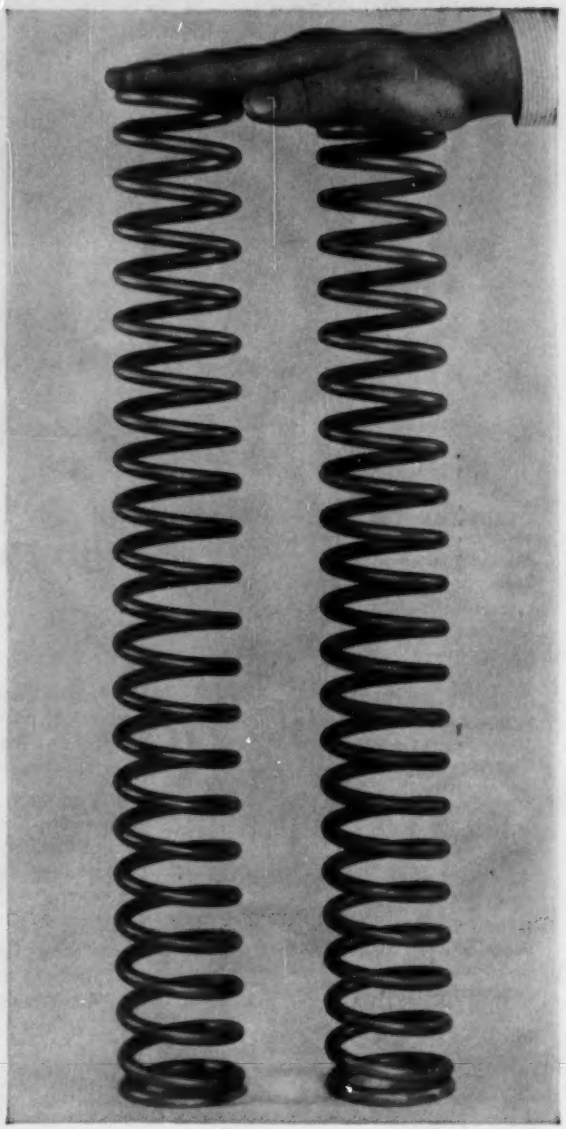
● FIBROUS AND METALLIC PACKINGS FOR EVERY INDUSTRIAL PURPOSE

What New Metal-

Has closed-door drawout...



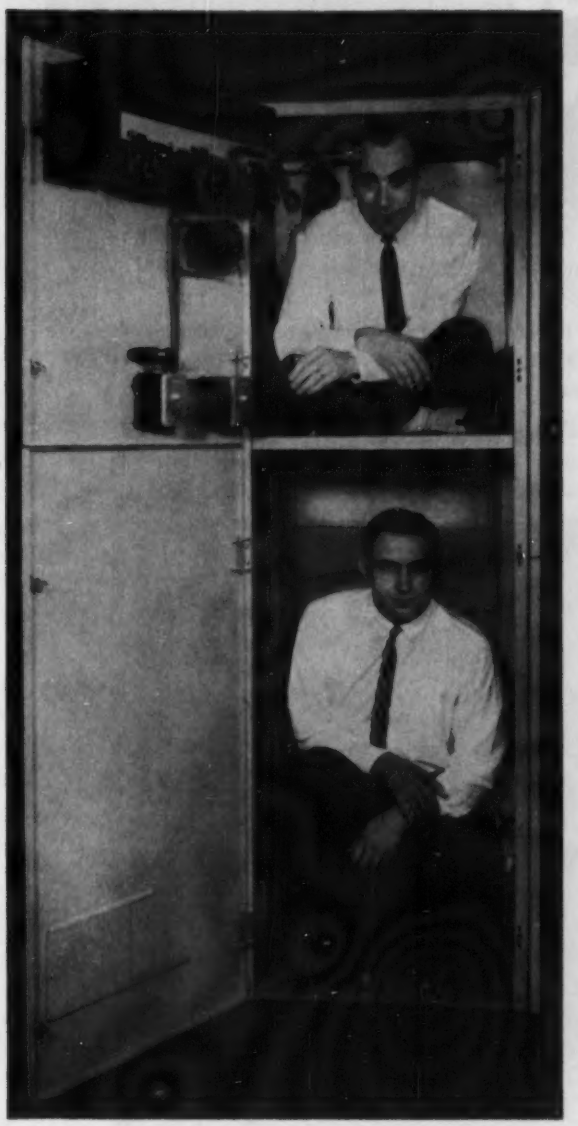
Stored energy as standard...



For complete answer, send for new illustrated Bulletin 2801-2A. And ask to see sound strip film that shows you every detail in only 18 minutes. Can be shown to you singly or to your group. Contact your nearby I-T-E sales office. Or write I-T-E Circuit Breaker Company, Dept. SW, 1900 Hamilton St., Phila. 30, Pa.

Clad Switchgear...

More elbow room inside...



Yet fits in tighter spaces?

I-T-E CIRCUIT BREAKER COMPANY

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DODGE HAS MORE PROVED BEARINGS THAN YOU HAVE BEARING PROBLEMS!

It pays to buy from a line of stock bearings—bearings that have been proved in thousands of installations similar to yours. You benefit by getting known dependability; and you get the important savings of high quality at production price.

PIN-POINT SELECTIVITY

Dodge has supplied mounted bearings to industry for over three-quarters of a century. Dodge bearings have always kept pace with improved production practices. Each new condition of service has been met by Dodge as it has arisen, with the result that the Dodge line contains mounted bearings to meet almost every service requirement with pin-point accuracy.

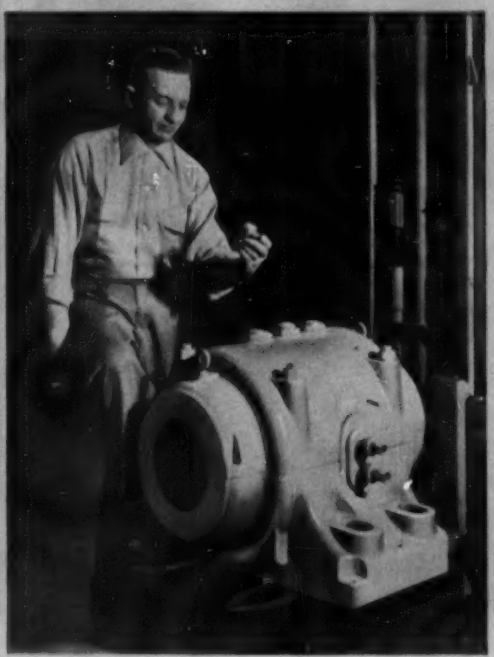
High load, high speed, excessive dust, moisture, corrosion, high or low temperatures, continuous operation—you name it!—such conditions and their combinations are met every day with Dodge bearings.

BROAD LINE—WIDELY DISTRIBUTED

In the great variety of mounted bearings developed by Dodge, you will most likely find the precise unit to fit your requirements ideally—without paying for features you do not need. And if your requirements call for several types of bearings, there is an advantage in having them of common design, such as Dodge offers.

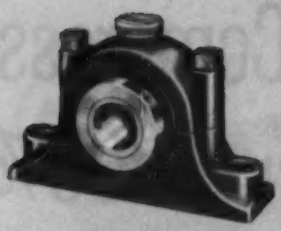
The Dodge line is probably broader than any other line of mounted bearings in America. And of special importance to machinery manufacturers, it is the most widely distributed line. There is always a Dodge bearing of the right type and size near at hand.

You can check this with your local Dodge Distributor. Ask him—or write us for the Dodge Bearing Bulletin.

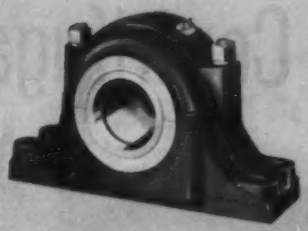


In addition to tapered roller, spherical roller and ball bearings, Dodge builds many types of sleeve bearings. Here is the "large and small" of the sleeve type bearings carried in stock—ranging from an 8-in. Sleevoil weighing over 1200 lbs. to a ½-in. solid journal bearing weighing 9 ounces.

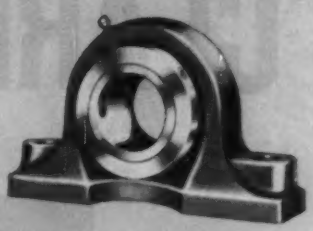
DODGE MANUFACTURING CORPORATION, 3200 Union Street, Mishawaka, Indiana



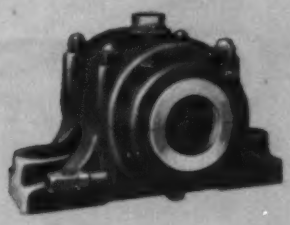
DODGE PILLOW BLOCKS WITH TIMKEN TAPERED ROLLER BEARINGS



DODGE SPHER-ALIGN PILLOW BLOCKS WITH SPHERICAL ROLLER BEARINGS



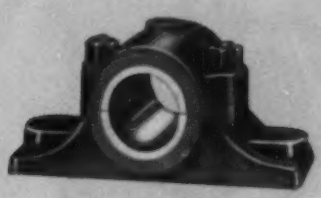
DODGE BALL BEARING PILLOW BLOCKS



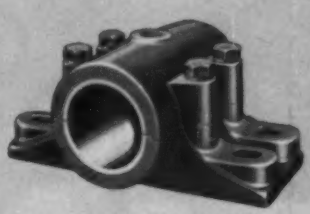
DODGE SLEEVOIL PILLOW BLOCKS

DODGE BRONZOIL PILLOW BLOCKS

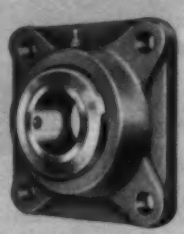
DODGE BRONZE BUSHED PILLOW BLOCKS



DODGE JOURNAL BEARINGS SOLID AND SPLIT



DODGE HEAVY RIGID PILLOW BLOCKS



FLANGE BEARINGS: HANGER BEARINGS: BEARING UNITS: TAKE-UPS

● **Dodge Pillow Blocks with Timken Tapered Roller Bearings.** America's quality pillow blocks. Assembled, lubricated, adjusted and sealed at the factory. 5 types for varying needs.

● **Dodge Spher-Align with Spherical Roller Bearings.** Rugged heavy duty, compact, inherently self-aligning. Exclusive Micro-Mount simplifies installation.

● **Dodge Ball Bearing Pillow Blocks.** Deep groove ball bearings with long inner races—high capacity. SL, SC and SCM models for light, normal and medium service respectively.

● **Dodge Sleevoil Pillow Blocks.** Ultra quality . . . extra long life . . . accessibility . . . *quiet*. Plain or water-cooled.

● **Dodge Bronzoil Pillow Blocks.** Efficient, low cost pillow blocks with self-oiling, capillary bronze bushings. Self-aligning. Large oil reservoirs.

● **Dodge Bronze Bushed Pillow Blocks.** Quiet fan and blower pillow blocks with two bronze bushings of high lead content mounted in one cast iron housing.

● **Dodge Journal Bearings—Solid and Split.** True running, dependable. Babbitted bearings with precision machined bores and faces. Finished bases.

● **Dodge Heavy Rigid Pillow Blocks.** Rugged, carefully bored, babbitted pillow blocks for many applications requiring grease lubrication. Finished bases and ends.

● **Bearing Units.** A wide variety—spherical seat, cartridge, flange, hanger, screw conveyor hanger, take-up. Ball, Roller and Sleeve types.

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under "Dodge Transmissioneer" in the *white* pages of your telephone directory, or in the yellow pages under "Power Transmission Machinery."

DODGE

of Mishawaka, Ind.

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CLARK Centrifugal Compressors Assure 100% Availability

Typical Clark Isotemp Compressor installation with synchronous motor drive and gear located on mezzanine level.

In air separation plants throughout the world, Clark Horizontally-Split Centrifugal Oxygen Compressors are operating in 100% service. Because the Type HS Compressors are literally maintenance free, standby units have not been required. The performance of these machines has been outstanding with safety, dependability and efficiency being among the features "best liked" by operators.

Now, another centrifugal compressor has been added to the Clark line of air separation compressors. The new Clark Isotemp Centrifugal Air Compressor has been designed to provide highest purity, primary 110 psi. air for tonnage oxygen plants. Like the Type HS Oxygen Compressors, the *Isotemp* is designed for 100% availability. It incorporates many of the design features found to be so effective in the oxygen machines.

A key feature of the Clark Isotemp Compressor is the system of integral intercoolers. Built into the base of machine, they form a compact unit-engineered package. An unusually high efficiency over a wide operating range is produced by intercooling between stages, the use of closed-type impellers and volute diffusers. Single-case, horizontally-split design assures maximum accessibility and eliminates alignment problems.

If you need high purity compressed air in large volumes, the Clark *Isotemp* will provide substantial savings in capital investment, space, foundation requirements, maintenance and operating costs. The *Isotemp* is built in seven frame sizes in packages with capacities ranging from 5000 to 50,000 cfm and more. Clark Oxygen Compressors are available in matching frame sizes. Both the Isotemp and Type HS units can be driven by synchronous motors, induction motors or turbines.

For data on Clark Centrifugal Compressors and Reciprocating Compressors consult your nearest Clark representative or write for Bulletin 175 on Isotemp Compressors, Bulletin 150 on Centrifugal Oxygen Compressors or Bulletin 160 on Clark Reciprocating Process Compressors.

CLARK BROS. CO.
OLEAN, N.Y.

ENGINES
COMPRESSORS
GAS TURBINES

CLARK DI DRESSER INDUSTRIES INC.
OIL • GAS • CHEMICAL
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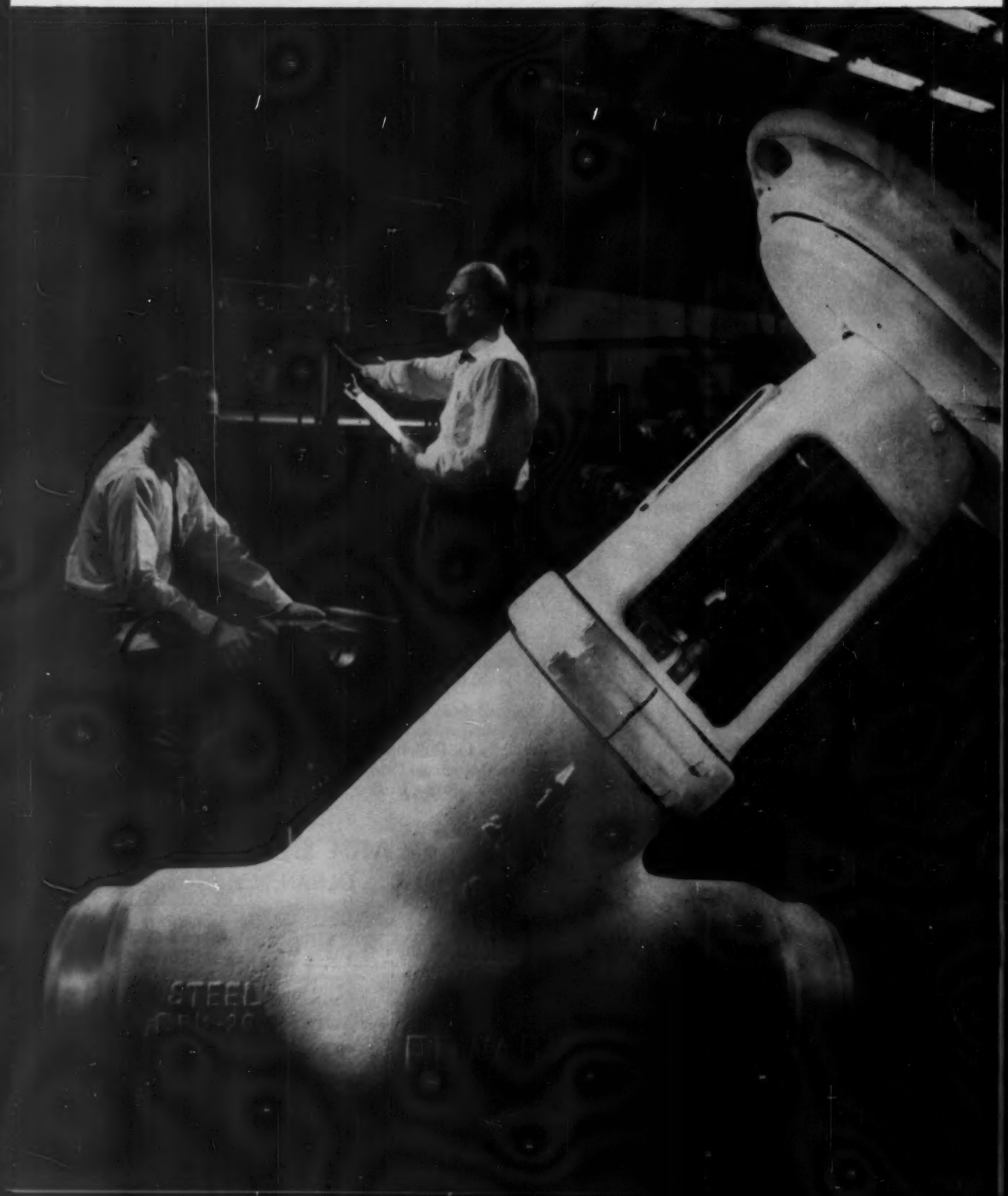
How Edward Valve Research



Reduced Pressure Drop 70%

Power industry advances in unit size created a need for large, high pressure steel valves (ten inch size and larger, 1500 lb class and higher) with three basic qualities: 1. Permanent tight seating; 2. Capacity to handle high flow rates being encountered in new, high pressure plants; 3. Reduced downtime through simplified maintenance. Edward researchers developed the Flite-Flow* design to satisfy that need. This is their story.

In 1951 Edward had already developed large cast steel globe valves with excellent dependability and repairability. Long experience in building inclined stem Y-type valves in small sizes indicated that this configuration offered a more efficient flow path. Edward research engineers set out to learn whether sufficiently strong pressure containing structures might be built in the Y-type design in larger sizes. They also sought to find out if pressure drop could be reduced sufficiently to make such a valve practical for high pressure power plant services.

The project consisted of three steps:

1. INTERNAL CONTOUR DESIGN—Flow tests were conducted with a series of plastic models. Early in the testing program it was observed that flow capacity was not always directly related to the size of the opening. Reduction of turbulence proved to be even more important. This eventually led to subtle internal contour changes to pre-shape the flow before passing through the valve seat. More material was added to certain internal areas to gain additional structural strength.

2. DISK GUIDING TESTS—To compensate for the angular position of the stem-disk assembly tests were conducted to determine whether conventional three-point guiding used in vertical stem Edward valves would be adequate for the inclined stem design. Experiments suggested that four equally spaced guiding surfaces would be superior. This is important in floating disk types such as check or stop-check valves where disk-piston assembly must seat automatically.

*T.M. Reg. U.S. Pat. Off.

3. STRUCTURAL STRENGTH—The usual weakness of a Y-type pressure containing vessel received much attention. Optimum valve contour as determined by flow testing permitted use of a structural member in the flow passage at the downstream side of the seat port. This structural member provides strength exactly where needed without significant increase in pressure drop. Introduction of this segment to the valve body casting without sacrifice in pressure drop was a significant achievement.

RESULTS: This program covered a period of six years. Tests of the completed design were most gratifying. Structural stability, a major problem, was excellent. Strain gage and brittle lacquer tests of finished valve bodies showed stresses well within acceptable limits. Pressure drop reduction amounted to as much as 70 per cent from best previous globe valve experience. Extended tests of finished product at pressures and temperatures above rating showed no operating weaknesses. The Flite-Flow is truly a dependable, repairable, low pressure drop valve.

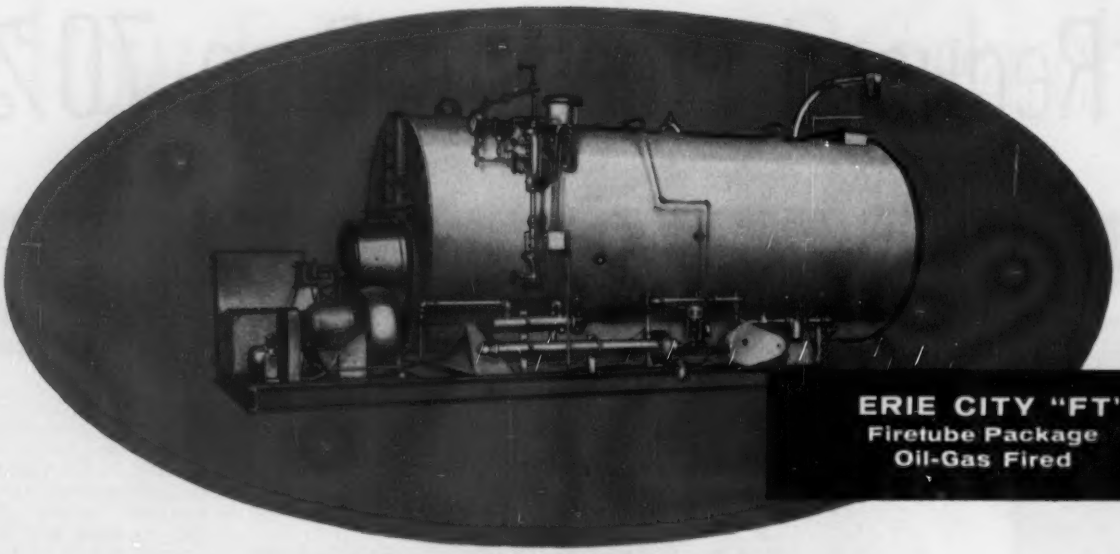
Edward builds a complete line of forged and cast steel valves from ¼" to 24" for industrial, marine, petroleum and technological services. For more detailed information, contact your Edward Representative, or write Edward Valves, Inc., 1230 West 145th Street, East Chicago, Indiana. Subsidiary of Rockwell Manufacturing Company. Represented in Canada by Lytle Engineering Specialties, Ltd., 438 St. Peter Street, Montreal.

EDWARD STEEL VALVES
another fine product by
ROCKWELL

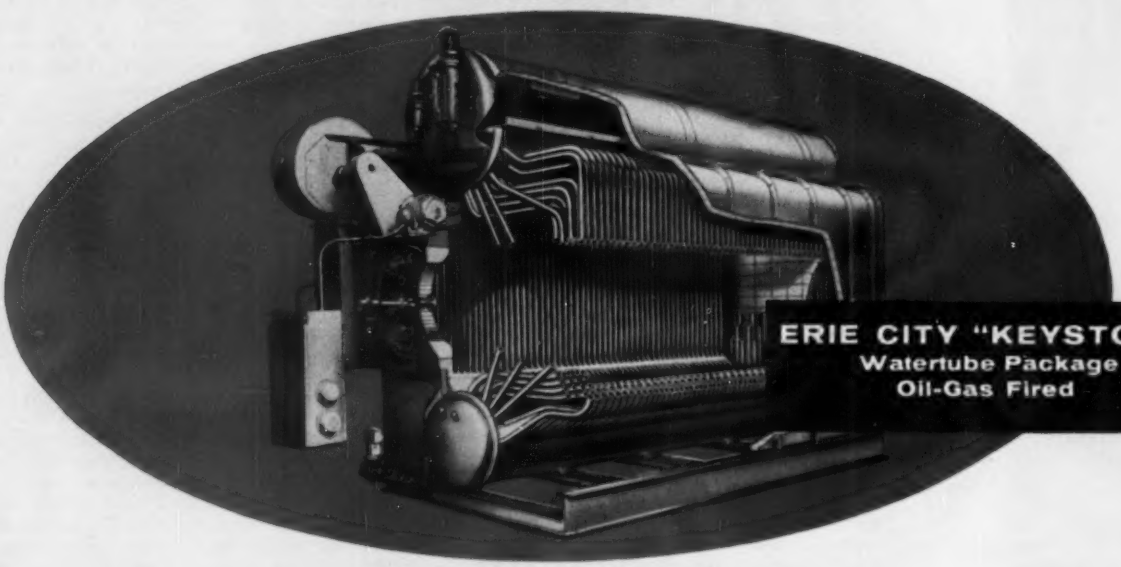
◀ W. G. Lunt, research engineer, and E. B. Pool, chief research engineer, study flow phenomena in plastic half-model of tentative Flite-Flow design.

▼ Edward research team lowers experimental valve into test furnace where it is subjected to prolonged extremes of heat and pressure. This was one of the final steps in the development of Flite-Flow valve design.

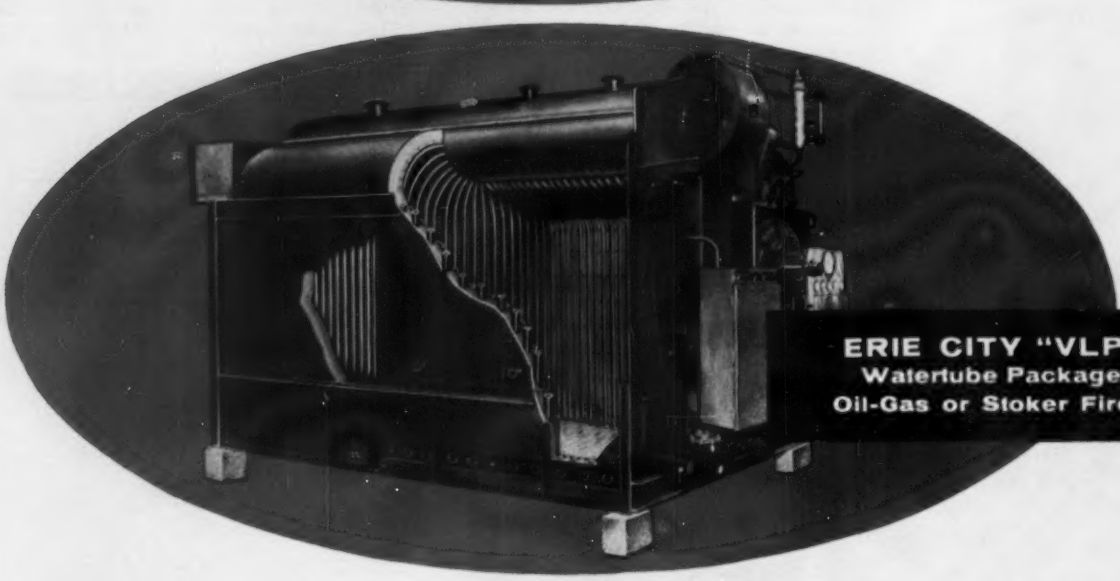
Cutaway view of Flite-Flow valve showing how inclined stem Y-type valve configuration has been adapted to larger size units for power plant services. This internal contour design enabled Edward research engineers to substantially reduce pressure drop.



ERIE CITY "FT"
Firetube Package
Oil-Gas Fired



ERIE CITY "KEYSTONE"
Watertube Package
Oil-Gas Fired



ERIE CITY "VLP"
Watertube Package
Oil-Gas or Stoker Fired

Why shop around for Package Boilers?

Thinking about a new boiler these days? Maybe a package boiler! Sounds like a good idea because many people like this new concept of undivided responsibility. But what kind should we get? Firetube? . . . Watertube? Should it be oil fired, gas fired, arranged for future stoker firing; or which combination of these would be best for us?

The best place to find unbiased answers to your questions is Erie City Iron Works—a pioneer in the boiler industry and a leader in the package steam generator field. Erie City manufactures both firetube and watertube package units. Without prejudice their engineers can point out the advantages of both types.

After hearing the pros and cons of each, you may decide on the firetube type. Erie City offers its modern "FT" Package Boiler arranged with Erie City air atomizing oil gun and/or ring type gas burner. The "FT" Fire Tube Package unit is built to highest quality standards—not down to a price. It is a three pass design with gas vent at the rear and pressurized, using forced draft to provide precise control of excess air and CO_2. A centrifugal fan is used, which coupled to a closed combustion chamber, results in unusually quiet operation. No costly foundation—no expensive stack—no brickwork are required.

If a watertube boiler is your choice, you have two types available from Erie City. One is the KEYSTONE, the most compact water tube package available, arranged with a steam atomizing oil gun and/or ring type gas burner. The KEYSTONE is a baffleless, two drum unit completely water cooled with a seal welded inner casing and bolted outer casing for pressurized operation. No costly foundation—no expensive stack—no brickwork are required.

The other choice for a watertube package is the VLP. Your plant may be located in an area where gas, oil and coal are all available. At first you may decide to fire with oil or gas but desire the proper provision for future coal firing. The boiler for you to install is an Erie City VLP arranged for present oil and gas firing but with the furnace PROPERLY PROPORTIONED for the future installation of an underfeed or spreader stoker.

All Erie City package units come complete with burners, fans and safety and combustion controls, piped, wired and mounted on the boiler. No field work required—just make basic fuel, water, steam and electric connections and you're ready for operation.

Both the air atomizing and steam atomizing burners are of Erie City's own design and manufacture. No division of responsibility here. Qualified service engineers will assist at start up and instruct your operating personnel. In the case of the VLP, your boiler will be properly designed for future conversion to either Erie City underfeed or spreader stoker firing. Again, no division of responsibility.

Don't let the selection of a new boiler become an unnecessary problem. Write and let Erie City help make the proper selection of a package steam generator for you.

"FT" *Cat.* SB5601H

"KEYSTONE" *Cat.* SB6301H

"VLP" *Cat.* SB5701H

• *You can depend on* ERIE CITY Since 1840 *for sound engineering*

ERIE CITY IRON WORKS *Erie, Pennsylvania*

STEAM GENERATORS • SUPERHEATERS • ECONOMIZERS • AIR PREHEATERS • WASTE HEAT BOILERS
FIRE and WATER TUBE PACKAGE BOILERS • OIL and GAS BURNERS • STOKERS • PULVERIZERS

RUGGED ZEBRA

NEW

the multi-layer pipe insulation that goes on fast!

There's nothing dainty about new "K&M" Zebra. Its rugged, full body lets you work fast . . . almost forget about handling breakage. And once it's in place, this low, medium and high-temperature thermal insulation stands up to intense vibration—won't crack or warp from shock or heat . . . as proved in tests by K&M and independent testing laboratories.

Another Zebra advantage is this: it's made in half sections exclusively . . . even for the larger pipe sections. The result is speedier application with fewer joints. Zebra is also relatively lightweight . . . easy to cut and fabricate. It can be re-used . . . dismantled and re-applied. No skin abrasion or cuts either. Zebra has a smooth surface.

Write today for more information and a free sample of "K&M" Zebra—the rugged new pipe insulation that's fast to apply. Keasbey & Mattison Company, Ambler, Pa. Dept. I-180.

• for temperatures of 200° F to 1200° F • made of calcium silicate-asbestos fiber bonded felts • meets requirements for density, conductivity, modulus of rupture, and resistance to soaking heat • available in a wide range of sizes and thicknesses.

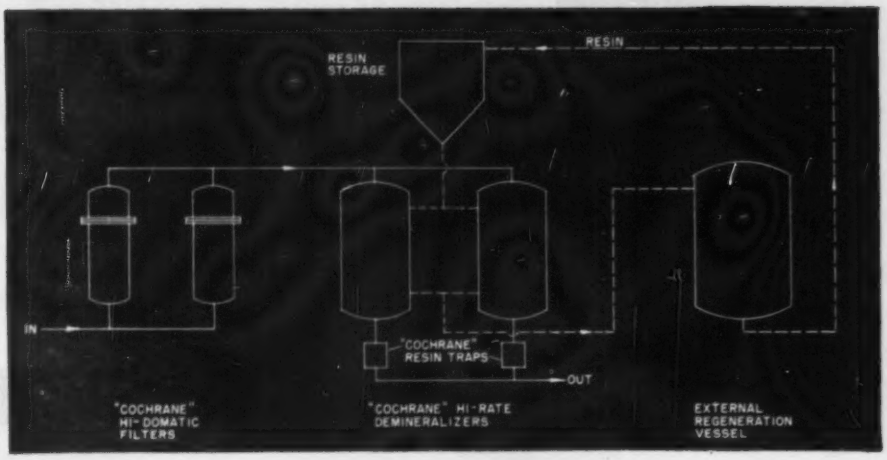
Keasbey & Mattison at Ambler

K·M
BEST IN ASBESTOS

For more facts circle 238 on Reader Service card, p. 119

Cochrane
CORPORATION
3106 N. 17th Street, Philadelphia 32, Penna. also New York & Chicago
Representatives in thirty-six principal cities in U.S., also Havana, Cuba; Paris, France; La Spezia, Italy; Mexico City, Mexico; Caracas, Venezuela; Santiago, Chile; Manila, Philippine Islands.
COCHRANE WATER CONDITIONING LIMITED, Toronto, Montreal, Winnipeg, Canada • POTTSTOWN METAL PRODUCTS DIVISION Custom built carbon steel and alloy products.

CONDENSATE SCAVENGER FILTER-DEMINERALIZERS



Typical Flow Diagram

Cochrane has pioneered the development of condensate scavenger demineralizers for high pressure boilers, including auxiliary resin transport and external regeneration equipment.

In addition to extensive experience in this relatively new area of water treatment, Cochrane offers the advantages of single responsibility and integrated design and manufacture. The complete scavenger system is Cochrane-designed and fabricated, including:

HI-DOMATIC tubular septum precoat filters.
High rate mixed bed demineralizers.
Resin Traps.
Resin transport system with special overhead resin storage.
External regeneration units.

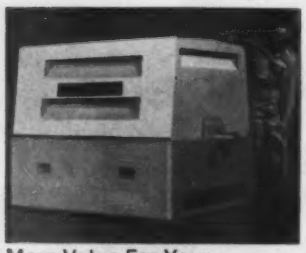
RECENT COCHRANE CONDENSATE SCAVENGER PLANT SYSTEMS

	Location	Boiler Pressure psi	Boiler Evaporation lbs/hr.
Government Agency	Tennessee	nuclear	nuclear
Public Utility	Ohio	3500	1,250,000
Utility	Genoa, Italy	2000	1,000,000
Government Utility	Alabama	2400	2,450,000
Utility	Levante, Italy	2700	1,000,000
Utility (Repeat Order)	Levante, Italy	2700	1,000,000
Public Utility	New Jersey	2400	2,350,000

Write for further information on Cochrane condensate scavenger systems.

Demineralizers • Zeolite Softeners • Hot Process Softeners • Hot Lime Zeolite Softeners • Dealkalizers • Reactors • Deaerators
Pressure Filters • Continuous Blowoff Systems • Condensate Return Systems • Steam Specialties

For more facts circle 239 on Reader Service card, p. 119

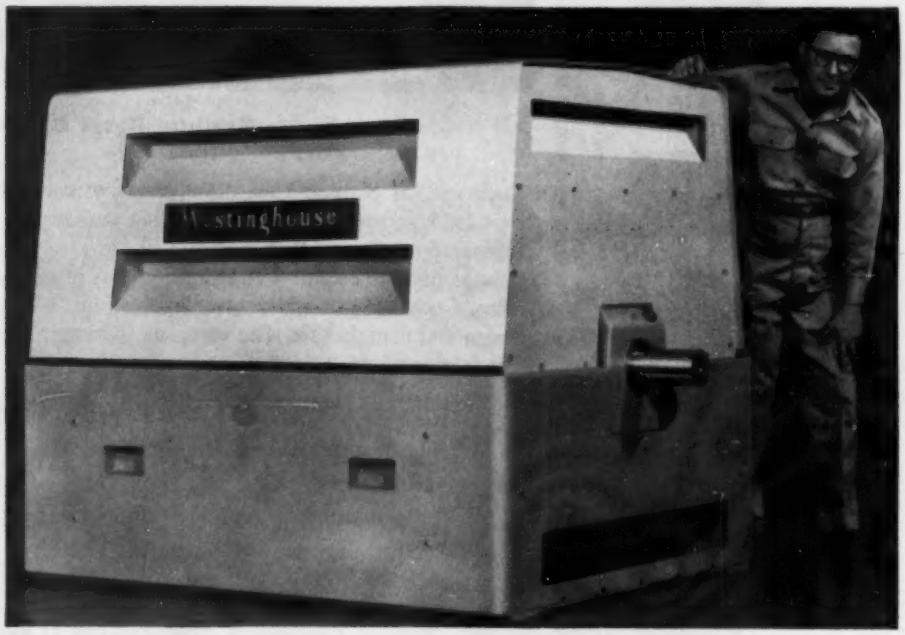


More Value For Your Large Motor Investment . . .

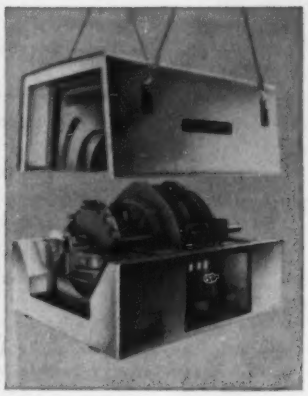
Westinghouse F/A Motor design

There's an F/A Motor enclosure to meet any of your installation requirements with standard horizontal drip-proof construction . . . NEMA weather-protected enclosures for normal *and* totally unprotected outdoor locations . . . totally enclosed fan-cooled tube-type motors and those having a cooler or heat exchanger.

Each sturdy F/A Motor enclosure is completely separate from the stator and can be removed in minutes for thorough visual motor inspection. In addition, inspection of leads, connections, windings and bearings is simple and quick . . . complete motor disassembly and reassembly take an average of only 3½ hours! Result: unmatched accessibility. This accessi-



Standard horizontal drip-proof enclosure for F/A Motors (at right) gives full accessibility. Cover can be quickly lifted off; removing end panels allows routine inspection of windings and bearings; end panels, covers and air shields can be removed in only 38 minutes, replaced in 56—with the motor still in running condition.



TEFC tube-type F/A Motor enclosure is shown at far left. The tubes are all mounted in top of enclosure, as shown in the next picture, and the motor is completely accessible when enclosure is removed.

YOU CAN BE SURE...IF IT'S

wraps economies in a variety of enclosures

bility, coupled with the time-tested and -proved reliability of Westinghouse motor components, can save you up to 75% on inspection and maintenance.

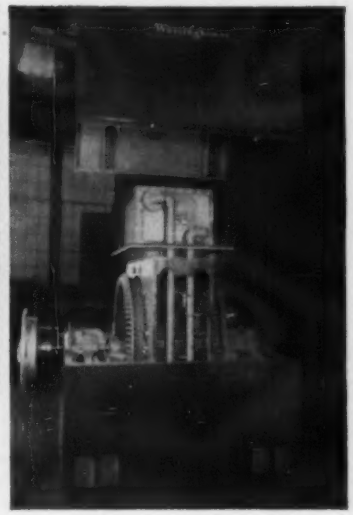
THAT'S NOT ALL. F/A Motors have unique Thermalastic® insulation which has been protecting coils in more than 50,000,000 kw of Westinghouse large rotating apparatus. Extensive testing shows that Thermalastic has a probable 100-year life. And F/A Motors are super-quiet . . . virtually eliminate the annoying whine typical of large motors.

Check today for full information on Westinghouse F/A Motors. Your nearest Westinghouse representative has details . . . or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

J-15018

Weather-protected enclosures: At left is the NEMA Type I weather-protected F/A Motor that's perfect for normal outdoor installations.

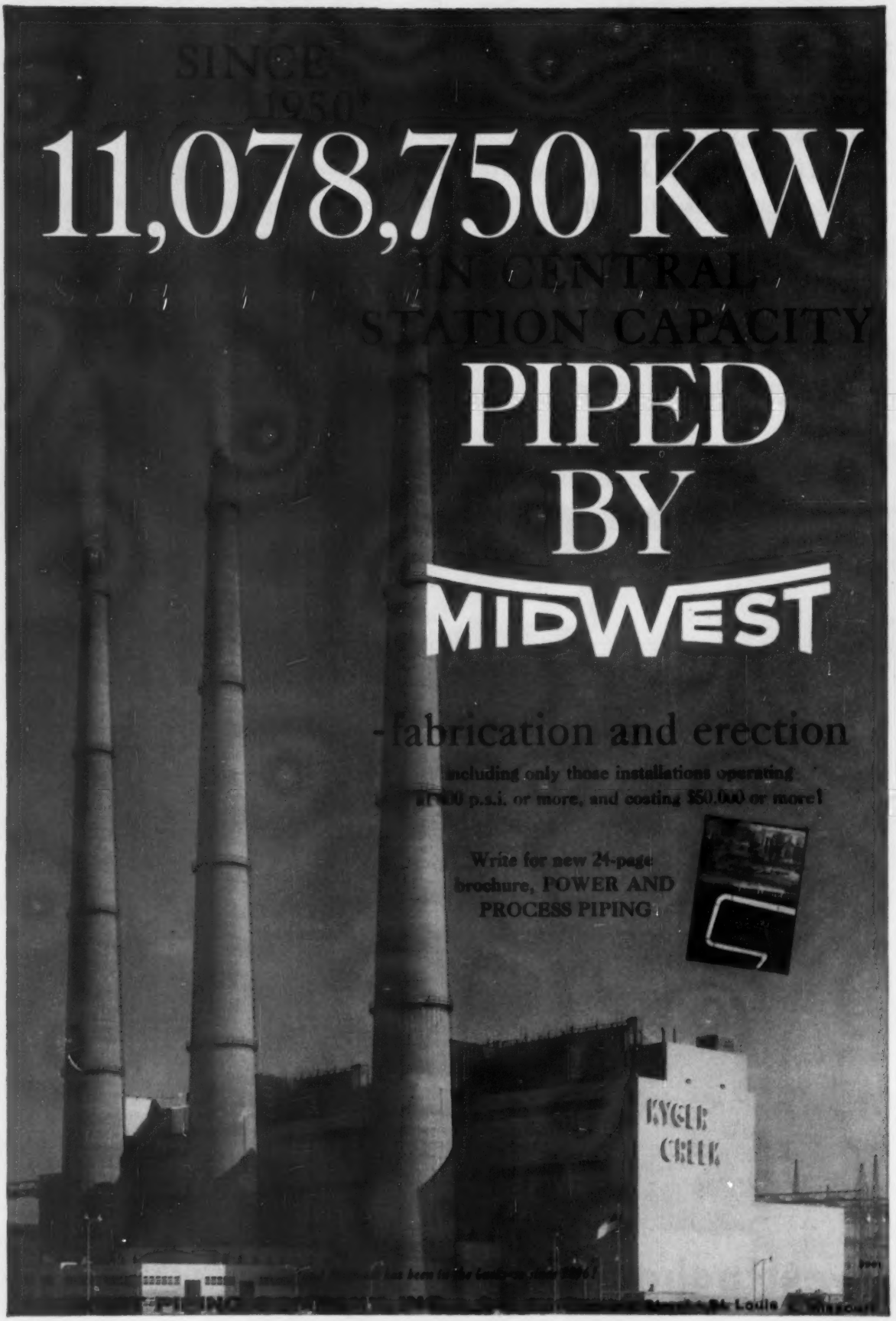
Right, a NEMA weather-protected Type II F/A Motor enclosure which provides maximum protection where adverse weather conditions prevail.



Enclosure for motors with cooler: Note the cooler is inside the enclosure, which can be quickly taken off to expose the cooler and internal motor components as demonstrated at right. Full accessibility of all F/A Motors means substantial savings on inspection time and dollars.

Westinghouse

For more facts circle 240 on Reader Service card, p. 119



For more facts circle 241 on Reader Service card, p. 119

LOUIS N ROWLEY, EDITOR • AUGUST 1960 • ESTABLISHED 1882 Power

Want to cut your reading time?

In these busy days, it's hard to imagine any engineering executive who wouldn't answer that question with a loud "Yes." All of us struggle to cope with a swelling flow of memos, reports, technical articles. We cannot ignore the job-important information carried in this stream of reading matter; we *must* take the time needed to extract it. How can we do this job faster and so gain precious extra time for thought and action?

The efficient extraction of information from reading matter begins with the material itself. If it is organized, written and presented to move ideas from the page to the reader's mind with minimum friction, part of the job is done. This is a responsibility of all of us who write—whether it be a memo, a report, or a technical article. We on POWER have always been deeply conscious of this responsibility. We constantly seek to make it easier for you to decide which articles are interesting and useful to *you*. And in each article we strive to combine sharp, concise writing with effective display and illustration to make an *organized* whole that delivers facts fast and clear.

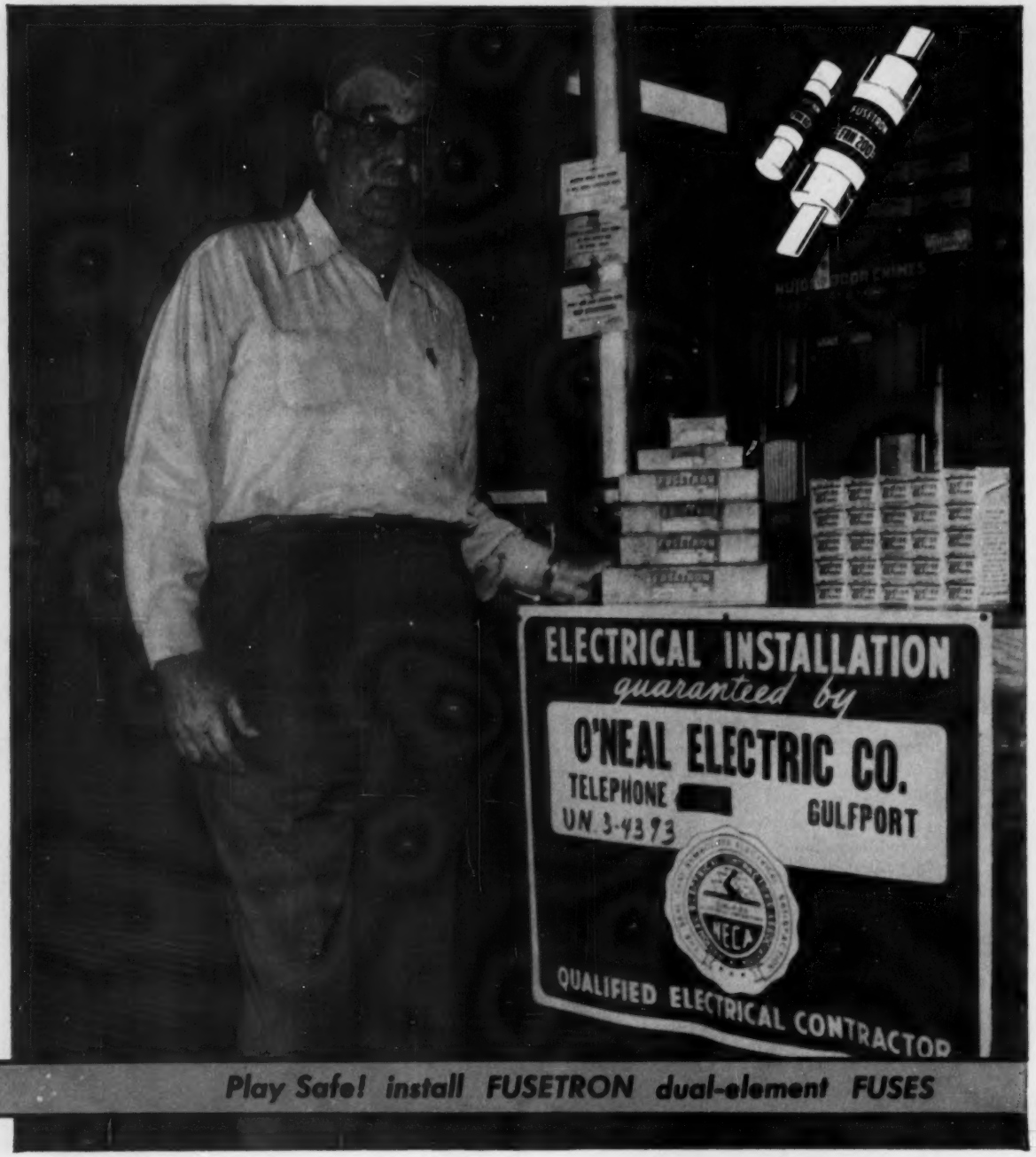
This, of course, is only the beginning. The bulk of the reading job rests with the individual and here is where application of new knowledge can yield big dividends. The average businessman, for example, reads at a rate of less than 250 words per minute. He depends on reading habits formed in grammar school, has made little effort to perfect his skill to meet the demands of adult life. Conscious effort to develop new reading habits, based on simple, easily learned techniques, can boost speed to 1000 words per minute or more. Just think what you could do with the time saved by multiplying your reading speed up to four times!

Skillful reading gives you a head start. It cuts down backlogs of reports and technical publications, frees you to think, plan and act. It makes you better informed over a wider area. When you read faster, you not only comprehend better, concentrate more intensely and save time, but you also increase the effectiveness and value of all your work.

You can now begin to realize these advantages very easily, because McGraw-Hill, in cooperation with The Reading Laboratory, Inc, has developed a condensed guide to faster, better reading. It's called "How to cut your reading time" and is available without charge to you as a POWER subscriber. Just circle No. 195 on the Reader Service card in this issue and you'll be ready to start your own "faster-reading" program and to reap its rewards.

"We helped a customer stop frequent outages and get safe motor protection . . . by recommending FUSETRON Fuses"

OSCAR O'NEAL SR., PRES.
O'NEAL ELECTRIC CO., GULFPORT, MISS.



Play Safe! install FUSETRON dual-element FUSES

Mr. O'Neal continues . . .

"Sometime ago, the Gulfport Ice Co., called us in to do their electrical maintenance work. At the time, they were having a great deal of difficulty with motor starting currents causing ordinary fuses to blow. They were using 100, 200 and 400 amp. ordinary fuses to protect the motors.

"These frequent outages disrupted the company's normal operation and created a costly and annoying situation. Just to replace the 400 amp., 250 volt ordinary fuses was costing them about $40 a month.

"My first recommendation to them was to change to Fusetron dual-element fuses in the proper size for safe motor protection. They did.

"The installation of Fusetron fuses was the 'key' to the problem. In the past five years I do not recall one 400 amp. Fusetron fuse having blown — and outages on the 100 and 200 amp. circuits have been very infrequent."

YOU TOO, CAN GUARD AGAINST UNNECESSARY OUTAGES OR MOTOR BURNOUTS THAT CAUSE MEN AND MACHINERY TO STAND IDLE SIMPLY BY INSTALLING FUSETRON DUAL-ELEMENT FUSES THROUGHOUT THE ENTIRE ELECTRICAL SYSTEM.

In addition to saving you money by protecting against needless outages and motor burnouts

FUSETRON Fuses offer High Interrupting Capacity and Life-Time Dependability Essential to Modern Protection.

High Interrupting Capacity: With electrical network capacities steadily increasing, — a *modern* protective device must be capable of interrupting the heavy fault currents now available and to be adequately safe to allow for anticipated growth in service demands.

FUSETRON fuses give you this protection. They have an exceptionally high interrupting rating of 100,000 amperes rms symmetrical.

Life-Time Dependability: The increase in available fault currents has emphasized the need for dependability in modern protective devices, otherwise, serious fire and personal injury can result should the device fail to operate when an emergency arises.

FUSETRON fuses provide safe and accurate protection through the years as their operation depends on a simple thermal law. Unlike mechanically operated devices, Fusetron fuses have no hinges, pivots, latches or contacts to stick or get out of order.

Once properly installed, Fusetron fuses require no maintenance, — no periodic inspection and accompanying down-time.

If you are considering a new installation or the modernization of an electrical system — you can be sure of modern, safe, maintenance-free protection in 10 or 20 years by installing Fusetron dual-element fuses now.

For more information on FUSETRON dual-element fuses . . . Write for bulletin FIS.

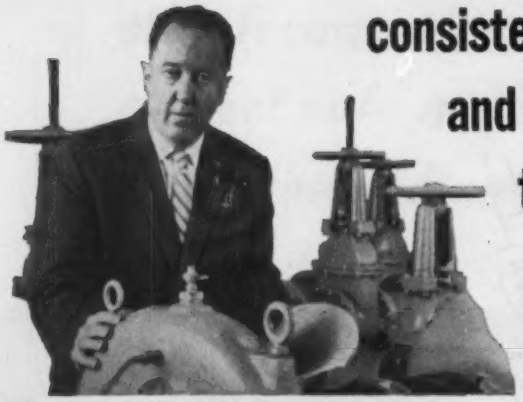
BUSSMANN MFG. DIVISION
McGraw-Edison Co.
St. Louis 7, Mo.

throughout entire Electrical System!

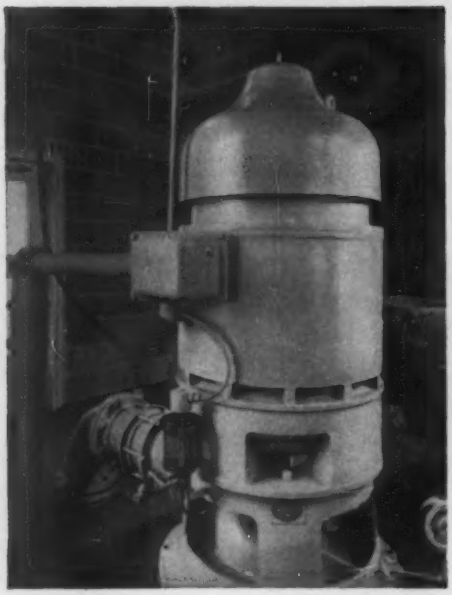
FUSETRON
TRUSTWORTHY GUARDS OF ELECTRICAL PROTECTION
BUSS
McGRAW EDISON

For more facts circle 242 on Reader Service card, p. 119

"We have found Peerless pumps consistently more efficient and longer lasting than any other pump we have used."



Says Joseph Kuranz, Manager, Waukesha Water Utility, Waukesha, Wisconsin



← "Even at our settings (400-500 feet) and with the severe abrasive action of the water bearing aquifers in our hard water area, we plan on getting 10 years service from these deep well turbine pumps before they need maintenance attention. And when we do remove a pump for inspection, we find there is notably less damage from abrasion in the Peerless equipment."

↑ In addition to the deep well turbine pumps, Peerless Type A booster pumps are in use at four stations. Capacities are approximately 1000-1200 gpm against heads of 170-180 feet.

PEERLESS PUMPS

Standardize on Peerless pumps for all your water supply and pumping needs. Like the Waukesha Utility, you'll find Peerless pumps last longer, cost less to maintain and do the job better. For full details on Peerless pumps for your application, write us or clip coupon below.

Putting Ideas to Work

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Peerless Pump

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New York; Detroit; Cleveland; Chicago; Indianapolis; St. Louis; San Francisco; Atlanta; Plainview; Lubbock; Phoenix; Albuquerque; Los Angeles; Fresno.

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Consult your telephone directory.

POW

Peerless Pump, Hydrodynamics Division, Food Machinery & Chem. Corp.
301 West Avenue 26, Los Angeles 31, California

Please send me Bulletins B-141 and B-1300 on Peerless Deepwell and Type A pumps.

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For more facts circle 243 on Reader Service card, p. 119

Design and equipment application section

B G A SKROTZKI
Associate Editor in Charge

QUALITY CONTROL includes tests under simulated operating conditions. Test stand above checks l-v fuses above 600 amp for temperature and voltage drop at rated current

New NEMA standards spell out tighter fuse performance

In both high- and low-voltage fuses insufficient standards have caused application difficulties. Now NEMA specifications permit engineers to take better advantage of economies and simplified systems practical with today's fuses

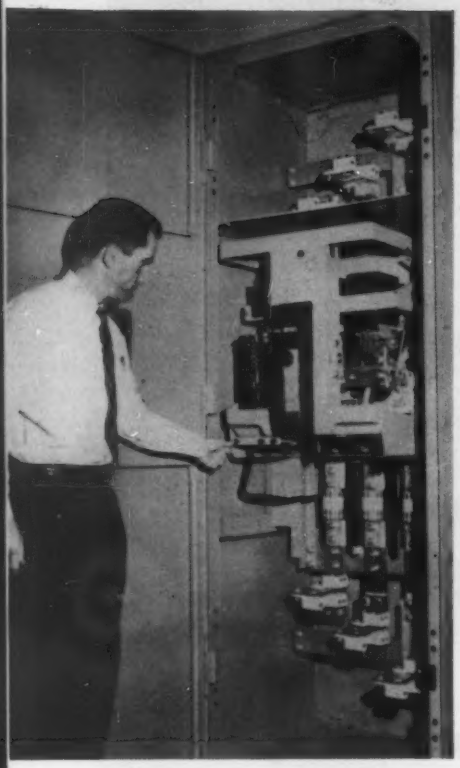
By NORMAN PEACH
Associate Editor

Important status of power fuses for protecting modern electrical-distribution systems is underscored by new NEMA Standards and revisions of National Electrical Code. Leading manufacturers build fuses to high standards under rigid quality control, but until now lack of an adequate national low-voltage standard has led to misunderstanding and weakened confidence in fuses. NEMA Standard FU 1-1959, *Low-voltage cartridge fuses*, is a milestone in the area of 600 v and less. It's a big step toward establishing the fuse as the precision protective device it inherently is.

Fuse technology has advanced in recent years, increasing continuous and interrupting ratings. Greatest interest has centered in current-limiting types, represented in both high and low voltages. Latest addition to the l-v family is a dual-element fuse, one element of which is current-limiting, p 73. Current-limiting fuses in combination with low-voltage circuit breakers are widely accepted—it's possible to use reasonably-sized breakers in networks where available short-circuit current is unusually large.

Above 600 v, load-interrupter switches have been further refined. They're now approved by NEC for circuits up to 25 kv; metal-enclosed or in vaults indoors, pole-mounted outside.

continued



C-L FUSES team up with manually operated stored-energy-closing air circuit breaker

L-v fuse design: now guided by comprehensive NEMA standards to insure performance

Four classes of low-voltage cartridge fuse are recognized in the new NEMA standards. These include all types in use today. (For fundamentals of fuse construction, application and performance see POWER's special report, *Electrical Distribution Protection*, June 1958.)

Before going into requirements for the four classes, let's look at some factors that must be considered when evaluating a fuse as a protective device. To begin with, a fuse must carry its rated current continuously without overheating — heating which would deteriorate fuse's insulation or increase contact resistance between fuse and fuse clips because of oxidation. When its rating is exceeded, the fuse must blow quickly enough to prevent thermal damage to the circuit it is intended to protect. Every fuse has an inherent inverse-time characteristic, but these differ greatly in different designs. Dual-element fuses use two different characteristics to combine overload and short-circuit protection.

Time current curves of specific fuse designs are essential for intelligent application of fuses and for coordination with circuit breakers and other fuses. Typical time-current curves (reduced in size and with abbreviated coordinates) are shown at lower right.

When a fuse blows, its fusible element melts, an arc is drawn and then the arc is extinguished. Melting time and arcing time are involved. All this happens very swiftly at maximum interrupting current; it takes only a fraction of one quarter cycle in current-limiting fuses. Successful interruption extinguishes the arc and prevents its restriking. This must be done without destroying fuse cartridge and with no excessive (harmful) venting of gases, flames or particles. *Interrupting rating* of fuse is highest direct current or rms alternating current that can be successfully interrupted.

Let-through current is maximum current that flows through fused circuit during a fault. Except with c-l fuses, let-through current is equivalent to available short-circuit current of the circuit. If it exceeds interrupting rating, fuse is likely to explode and other circuit components may be damaged. C-l fuses interrupt short-circuit current before it can rise to the maximum available value as determined by circuit parameters. Remember: c-l fuses have a let-through value (which they interrupt) for every value of available short-circuit current of circuit in which they are properly applied.

Recovery voltage across fuse increases rapidly when short circuit is interrupted. A high-voltage transient of many times fuse rating may occur before normal circuit voltage is restored. Fuse design must prevent restriking of an arc by recovery voltage during either transient or steady-state conditions.

NEMA fuse-class H covers a wide range of designs, including the familiar NEC fuse. Class H fuses may be built with interrupting ratings of 2, 5, 10, 25, 50, 100 or 200 thousand amperes. They must have an ac or dc interrupting rating or both, but manufacturer need not mark rating on the fuse when rating is below 10,000 amp. NEC fuses offer as proof of interrupting capacity the 10,000-amp-dc test which the Underwriters' Laboratories Standard requires. Some engineers have stated, however, that ac-interrupting capacity of *some* NEC fuses may be as low as 3000 amp.

Cartridge sizes are identified by familiar ampere designations—0 to 30, 31 to 60, etc—with dimensions and continuous-current ratings specified. Voltage ratings are: 250, 500 and 600 v dc; 150, 250, 300, 500 and 600 v ac. Fuses must perform satisfactorily at all voltages below rating.

Extensive tests are specified to be sure fuses carry their rated current without overheating and interrupt their rated maximum short-circuit current without external damage to the fuses. A further test specification is significant: "The normal-frequency alternating-current or direct-current recovery voltage across the terminals of the fuse shall be at least the rated voltage of the fuse. The recovery voltage shall be applied uninterrupted across the fuse for five minutes after completion of circuit interruption." This manufacturing requirement is intended to eliminate possibility of an arc establishing after interruption through tracking across a carbonized path between terminals.

Classes J, L and M have interrupting ratings of 200,000 amp, which must be marked on the fuse. J, L and M fuses are all ac. Class J fuses have different cartridge dimensions than

NEMA classes for l-v fuses

Class	H	J	L	M
Continuous amperes	600 or less	600 or less	601-6000	601-6000
Interrupting kiloamperes	varies	200	200	200
ac or dc	either or both	ac	ac	ac
c-l or not	either	c-l	c-l	not c-l

Class H, generally resulting in a smaller, space-saving fuse.

Since Classes J and L deal with current-limiting fuses, specifications spell out maximum peak let-through current, maximum threshold ratio and maximum clearing I^2t (at 100,000-amp symmetrical-rms available current: 600 volts, 60 cycles and less than 0.15 power factor). These quantities go a long way toward pinning down performance of c-l fuses.

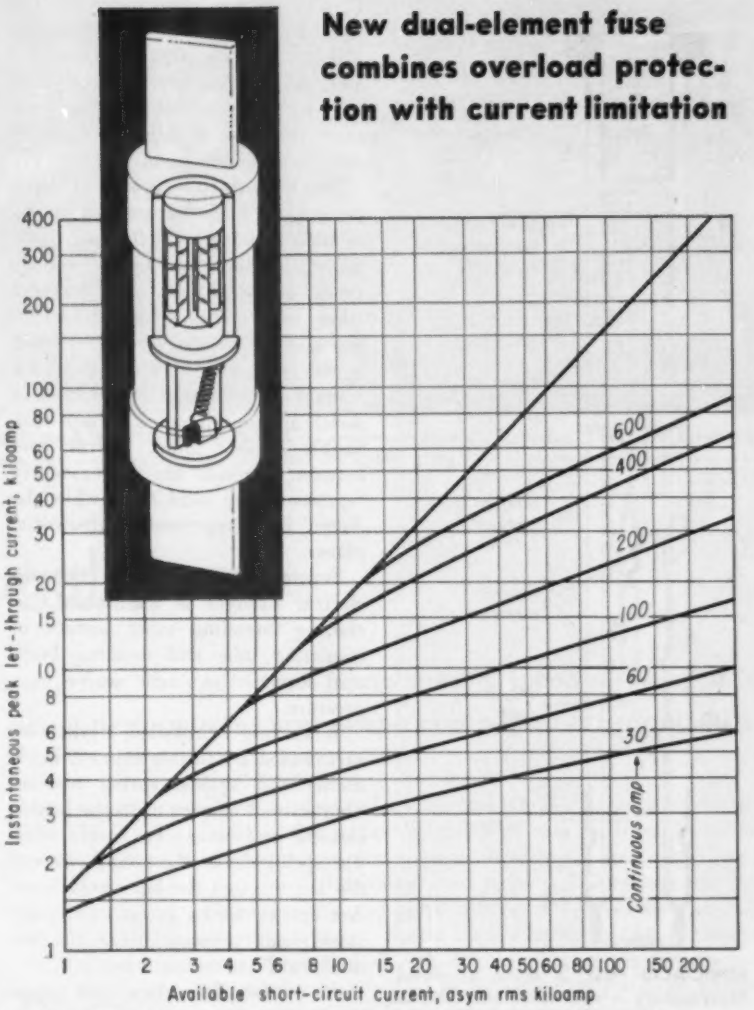
Threshold ratio is *threshold current* divided by fuse current rating. Threshold current is defined as "the symmetrical-rms available current at the threshold of the current-limiting range, where melting of the current-responsive element has occurred at approximately 90 degrees on the symmetrical current wave and total clearing time is less than one half cycle at rated voltage, rated frequency, and with a circuit power factor of less than 15%." This definition points out that degree of current limitation depends on fuse current rating and available short-circuit current of the *actual fault*. Curves at right show that under some conditions c-l fuses *aren't* current-limiting and may take more than one cycle to clear the fault.

Classes L and M extend l-v fuse range from 600 to 6000 amp, virtually eliminating need for paralleling fuses. C-l fuses are now made up to 6000 amp which appears adequate for present needs.

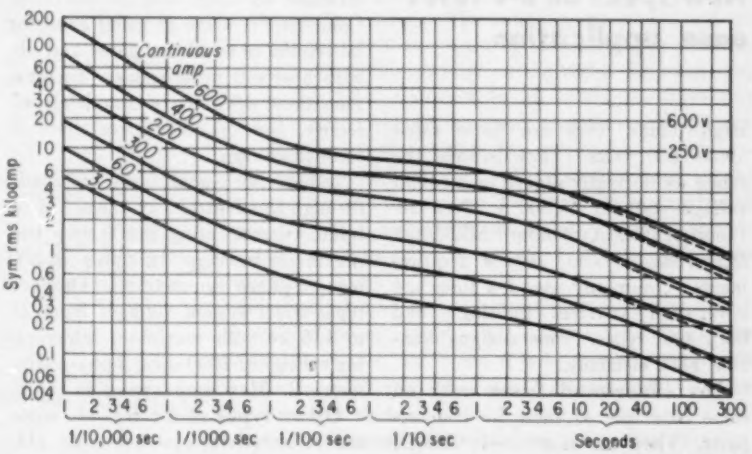
Dual-element c-l fuse, right, was recently introduced by one manufacturer. Fuse provides overload protection of the kind available from familiar dual-element fuses, but c-l element permits their use on circuits with as much as 200,000-amp available current. Range of applications is extended to correspond with circuit-breaker c-l-fuse combinations, so question of fuse vs circuit-breaker fuse combination no longer depends on current limitation.

New fuse has a distinct advantage over conventional one: it answers the single-phasing criticism frequently directed against fuses. When fuse is properly applied, increased current in remaining phase blows the overload element before connected equipment is damaged. In applications where dual-element fuses can be used advantageously instead of motor starters, new fuse has additional advantage of current limitation.

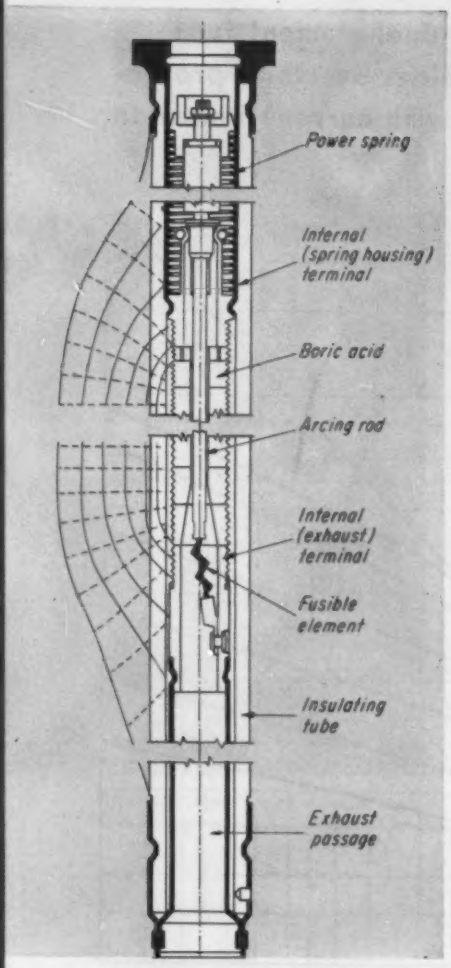
New dual-element fuse combines overload protection with current limitation



SHORT-CIRCUIT characteristics show how peak let-through current is limited to a fraction of available short-circuit current. Topmost curve represents maximum peak let-through current in circuit for given available s-c current. Fuses must, of course, interrupt let-through current without burning, exploding or restriking arc across terminals



OPENING TIMES for different ratings of fuse under various conditions of possible (prospective) short circuits follow curves. Curves diverge for 250- and 600-v types



BORIC-ACID FUSE is shown assembled. Superimposed is volts stress after blowing

New specs on h-v fuses ease application

High-voltage fuses are those rated above 600 volts. They include the range we normally regard as medium voltage—601 to 15,000 v. New revision of NEMA Standard SG2-1960, *High-voltage fuses*, details requirements. Commonly used h-v fuses are silver-sand (current-limiting) and boric-acid types. Some designs combine both elements.

H-v silver-sand fuses work on same principle as their l-v counterparts. They are nonvented; flames, gases or particles aren't expelled from the cartridge during interruption. Present voltage ranges from 2.4 to 34.5 kv. Continuous 100%-amp (NEMA E) ratings go as high as 200 amp, and interrupting ratings (which vary with voltage and E ratings) for some fuses are as high as 130,000-amp rms asymmetrical.

Boric-acid fuses come in many designs, but basic features are similar to unit sketched at left. Fuse illustrated handles the upper voltage range, above 34.5 kv, and its design takes into account high transient- and normal-frequency voltages which appear across fuse when it blows. Voltage-stress lines of blown fuses in sketch are superimposed on unit with fusible element intact. Stress lines between terminals are approximately represented by solid lines, while the dotted lines represent equipotential planes.

Several measures insure that dielectric strength is maintained, including threading inner surface of insulating tube and molding boric acid directly into tube under high pressure.

When fuse is installed, strain wire surrounded by fusible element holds arcing rod against spring tension. Short-circuit current melts the fusible element and severs the strain wire. The spring draws the arcing rod and the arc through the boric-acid bore. Arc energy forms gases, principally steam; gas pressure blasts the arc downward and extinguishes it.

An outdoor fuse often vents gases, flame and molten particles directly to the air. For indoor use in vaults or metal-enclosed switchgear, condensers, mufflers and "sneezers" may be attached to open end of the fuse. Condenser is made of metal gauze or labyrinths to condense gases and absorb heat and noise energy. In some sizes these devices are completely effective, but in other sizes there is some discharge.

Indoor boric-acid fuses are made through the 2.4-to-15-kv range. Maximum current rating is 600 amp and maximum interrupting rating is 500 mva, 3-phase symmetrical. Outdoor types cover system voltages from 23 to 138 kv with maximum interrupting ratings of 2000 mva, 3-phase symmetrical. Max amp rating is 300E.

Other types of h-v fuse see some use in industrial systems. Two old-timers still around are liquid-filled fuses and outdoor expulsion fuses—these are simpler cousins of the boric-acid fuse described, in some of which a fiber tube provides gas source.

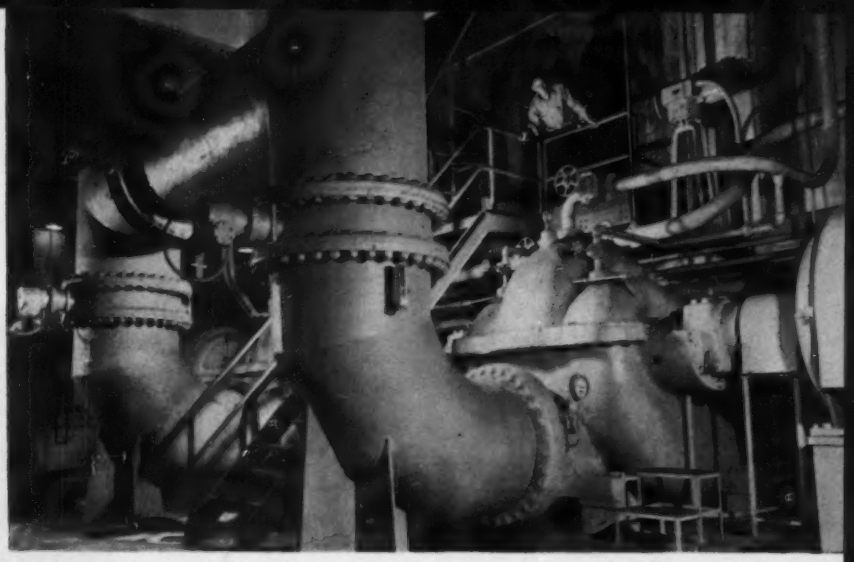
A newer, indoor nonvented type uses a different approach to current limitation than the silver-sand fuse. Fuse has two elements, one fusible. The other is a coil of fine molybdenum wire, which has the very-high melting point of 2620 C and functions as a nonlinear resistor. With low-current faults the fusible element interrupts without the molybdenum element coming into play. On high-current faults the molybdenum element heats rapidly, increasing its resistance. Fuse introduces a high impedance in the circuit which limits short-circuit current before interruption. These fuses have low ampere rating, 3E maximum, and are designed primarily for use with potential, control and auxiliary-power transformers on circuits with high available current.

Coordination of h-v power fuses requires that preloading be considered. NEMA Standards specify that time-current curves be based on tests starting at no initial load. In practice, however, fuses always carry some load, and occasionally are deliberately overloaded. Pre-loading raises temperature of the fusible element part-way to its melting point and so reduces melting time. Effect can be significant in many fuse designs, and precise coordination of power fuses with other protective devices means published time-current curves must be adjusted for preloading. Preloading-adjustment factors must be supplied by manufacturer for specific fuse designs.

Metal-enclosed load-interrupter switches have been widely accepted in recent years and can be expected to find yet-wider application in years ahead. Several manufacturers are busy developing their lines of this kind of switchgear, including roll-out fused load interrupters compatible with metalclad gear.

Economy and simplicity of fused switchgear recommend it for many jobs. Application is often advantageous in: (1) switching centers that are starting point for a system of feeders (2) high-voltage side of substations (3) main-substation-transformer secondaries and (4) single-bay service entrance for the incoming power of a simple radial system.

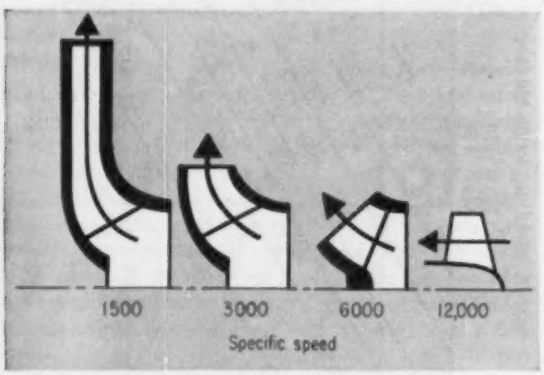
By H L ROSS, Manager
Centrifugal Pump Dept
Allis-Chalmers
Manufacturing Company



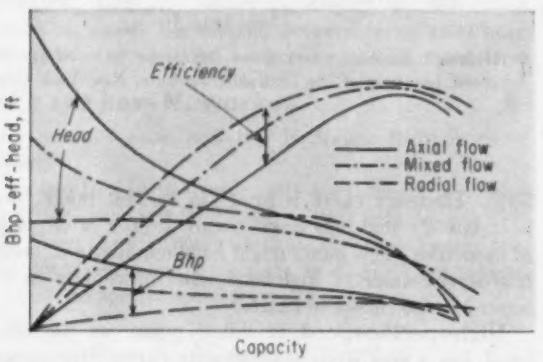
MEDIUM-SPECIFIC-SPEED PUMPS on condenser circulating service. These are horizontal split-case double-suction type designed for 35,000 gpm, 25-ft total head at 290 rpm

Use N_s to pick the right centrifugal pump

There's no mystery to centrifugal-pump specific speed — N_s. It tells you a lot about performance-curve shape and suction-lift capabilities



1 Impeller profiles for specific speeds from 1500 to 12,000: radial flow is shown at left, mixed flow center, axial flow right



2 Performance curves for various specific speeds show changes in the shapes of head-capacity-efficiency-horsepower curves

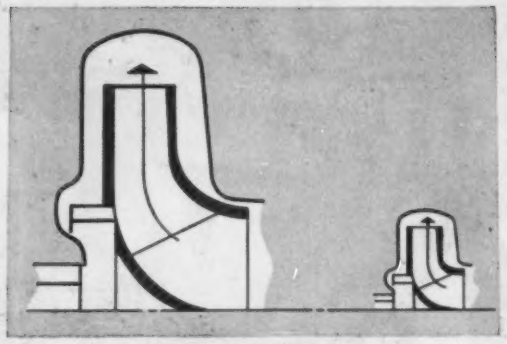
Specific speed of centrifugal pumps has long been considered the pump designer's private business in about the same way that some medical terms are doctors' prerogatives. But today purchasers and operators are becoming more and more interested in the effect of this important factor. Specific speed is significant in design and selection of all centrifugal pumps, but it perhaps has received least attention in high-capacity low-head pumps —condenser circulators are a prime example.

First let's see how specific speed classifies centrifugal pumps. N_s is independent of pump size but indicates a general shape for the pump impeller.

Of impellers shown in Fig. 1, one on the left has the lowest specific speed. Theoretically we could cut its diameter, speed it up—raising its specific speed, and proceed towards the impeller on the right. However, you can see that inlet diameters of all of the impellers stay about the same despite increasing specific speed. So cutting diameters and speeding up would soon mean prohibitive inlet velocities. Net positive suction head (npsh) would go through the ceiling. For this reason centrifugal-pump impellers are designed with particular specific speeds in mind and the change effect of varying impeller diameters is slight.

General shape of head-capacity-efficiency curves is affected by specific speed. Fig. 2 shows typical performance-curve shapes for three specific speeds, axial flow (N_s about 12,000), mixed flow (N_s about 6000) and radial flow (N_s about 1500).

Low-specific-speed radial-flow pump has relatively flat head-capacity and horsepower curves. Usually horsepower is lower at zero than at rated flow—as much as



A way to visualize N_s

A centrifugal pump's specific speed is defined as the speed a geometrically similar pump would have to run at were it designed to deliver one gpm against a total head of one ft. Its formula is:

$$N_s = \frac{N\sqrt{Q}}{H^{3/4}}$$

where: Q = gpm pumped
N = pump speed, rpm
H = total head, ft

To visualize this, picture a pump reduced in size until it delivers a flow of one gpm against a total head of one ft.

Remember the fundamental rules of centrifugal-pump hydraulics: capacity change is directly proportional to speed change, and head change is directly proportional to the square of speed change.

Now let's take a pump and shrink it down to get its specific speed. Assume a pump rated at 4000 gpm, 100-ft total head and 1200 rpm. First we slow it down until it produces only 1-ft total head. We must reduce speed by the square root of the head which means we'll cut it to 1/10 of 1200 or 120 rpm. Capacity, too, will go down, to 1/10 of 4000 or 400 gpm.

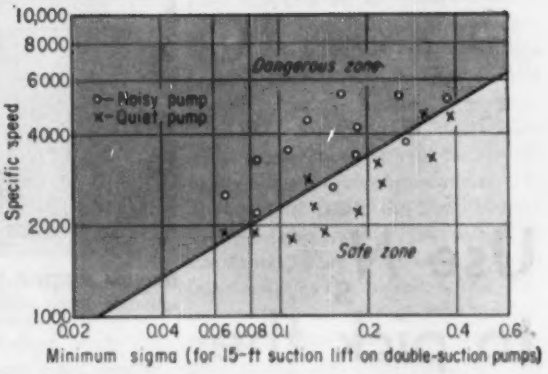
But we have not yet changed the size of the impeller—merely slowed it down. Now let's shrink the impeller but maintain its proportions. To reduce capacity to one gpm and still pump against the 1-ft total head, we must keep all velocities the same. So we reduce all areas down to 1/400 and all dimensions down to 1/20. However, if we reduce the impeller diameter to 1/20 of its former size but still maintain the same peripheral velocity, to get the 1-ft total head we must run it 20 times as fast.

We now have one gpm at 1-ft total head and 2400 rpm. This *2400* is the specific speed of the pump we started out with.

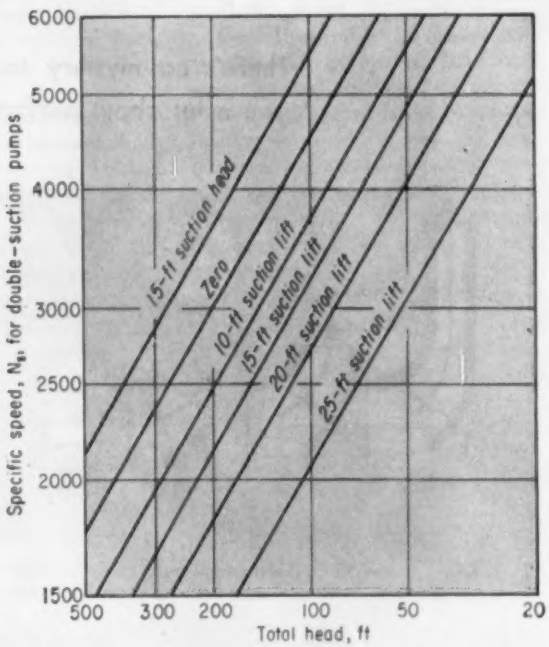
As a check, let's take the original pump-design conditions, substitute them in the centrifugal-pump specific-speed formula and see if we get the same answer:

$$N_s = \frac{1200\sqrt{4000}}{100^{3/4}}$$

$$N_s = \frac{1200 \times 63.2}{31.6} = 2400$$



3 Sigma curve plots zones of safe and dangerous operation. These early charts are bases of today's Hydraulic Institute curves



4 Hydraulic Institute curve shows the upper limits of specific speed (courtesy of the Hydraulic Institute, New York City)

50%. Efficiency curve is broad in its best range; that is, relatively high efficiency occurs over a wide range of capacities. This pump might handle boiler-feed, industrial-service-water or high-head waterworks duty in the upper low-specific-speed range.

High-specific-speed axial-flow pump, on the other hand, has a very steep head-capacity curve. Horsepower

also is much higher at zero flow than at rated capacity —as much as 2.5 times, and efficiency occurs over a narrow capacity range. Here it would be impractical to provide a motor driver with sufficient power to cover zero flow. So special care must be taken in installation to prevent low-capacity operation that would severely overload the motor driver. This pump might be a vertical wet-pit type for flood control or vertical-propeller pump for condenser circulating service.

So - called "mixed-flow" pumps lie between the high- and low-specific-speed ranges. These can be either horizontal or vertical wet- or dry-pit types. They usually find application as sewage pumps or moderate-head condenser circulators. Mixed-flow pumps overlap the specific-speed ranges of both low and high types, and there is no fine line of distinction between any of the ranges.

Effect of specific speed on suction conditions was not well understood 30 years ago. So higher and higher operating speeds were tried since, of course, this permitted smaller, less costly pumps and motors. But some pumps became noisy and cavitation problems developed. Most of these difficulties arose because the relationship between specific speed and allowable suction conditions was not well understood. There was no common method of relating these two factors.

At this point the Hydraulic Institute, a trade association of pump manufacturers, stepped in. As a first move all manufacturers pooled their information on problems relating to pump speed. Specific speed was plotted against a nondimensional coefficient called "sigma," defined as npsh divided by total head. Fig. 3 is typical of this accumulated data. A line was drawn to separate safe from dangerous zones. Of course there were exceptions due to unusually excellent or poor design, but the idea was to establish a line so that a well-designed pump under good conditions would operate satisfactorily with a fair margin. From the sigma plots, the more-familiar Hydraulic Institute specific-speed charts were derived.

Specific-speed chart, Fig. 4, adapted here from the Hydraulic Institute Standards, covers double-suction pumps. It shows the relation between pump total head and specific speed under various suction-lift conditions.

Let's see how N_s works

Two examples show how this Hydraulic Institute curve is used.

Example (1) A double-suction condenser circulator for 20,000 gpm at a total head of 60 ft is to have a 15-ft lift. From the Hydraulic Institute curve, maximum specific speed for these conditions is 4300. Then, substituting in the specific-speed formula:

$$N_s = \frac{N\sqrt{Q}}{H^{3/4}} \quad \text{or} \quad N = \frac{N_s \times H^{3/4}}{\sqrt{Q}}$$

$$N_s = \frac{4300 \times (60)^{3/4}}{\sqrt{20{,}000}} = 660 \text{ rpm}$$

We should select a motor speed that does not exceed 660 rpm. The next-lower full-load induction-motor speed is 585 rpm. But we could buy a less-expensive pump and motor if it could run at the next higher full-load induction-motor speed of 700 rpm. The specific speed of such a pump would be:

$$N_s = \frac{700\sqrt{20{,}000}}{(60)^{3/4}} = 4560$$

Maximum suction lift for a pump with a specific speed of 4560 at 60-ft total head is 13 ft. If we can lower the pump setting by two ft we can use the less-expensive arrangement.

Example (2) In the case of a 30-mgd waterworks pump designed for 20,800 gpm at 250-ft total head with 15-ft suction lift, we get an N_s of 2015 at a full-load induction speed of 880 rpm. However, referring to Fig. 3, the 15-ft suction lift specified is not permissible—about 12.5-ft max is shown. If the 15-ft suction lift cannot be reduced, a 700-rpm motor is required, giving a new N_s of about 1600. But considerable saving in first cost of both pump and motor is possible if suction lift can be reduced below 12.5 ft so an 880-rpm motor can be used.

Similar specific-speed-limitation curves are published by the Hydraulic Institute for all centrifugal pump types —single and double suction, mixed and axial flow. Special maximum-suction-lift curves cover hot-water, boiler-feed and condensate pumps.

Hydraulic Institute specific-speed curves are widely accepted by manufacturers, users and consulting engineers. They're revised from time to time to reflect advances in pump design. Most manufacturers will not recommend pumps for operating conditions that exceed these limitations, and in general, both users and consulting engineers specify that pump speeds shall not exceed those recommended by the Institute. This practice has greatly improved pump operation, reduced incidence of noise and pump damage due to cavitation. Continued and wider use of the standards will go a long way toward reducing operating difficulties and lengthening pump life through eliminating cavitation, the greatest enemy of centrifugal pumping equipment.

Want more information?

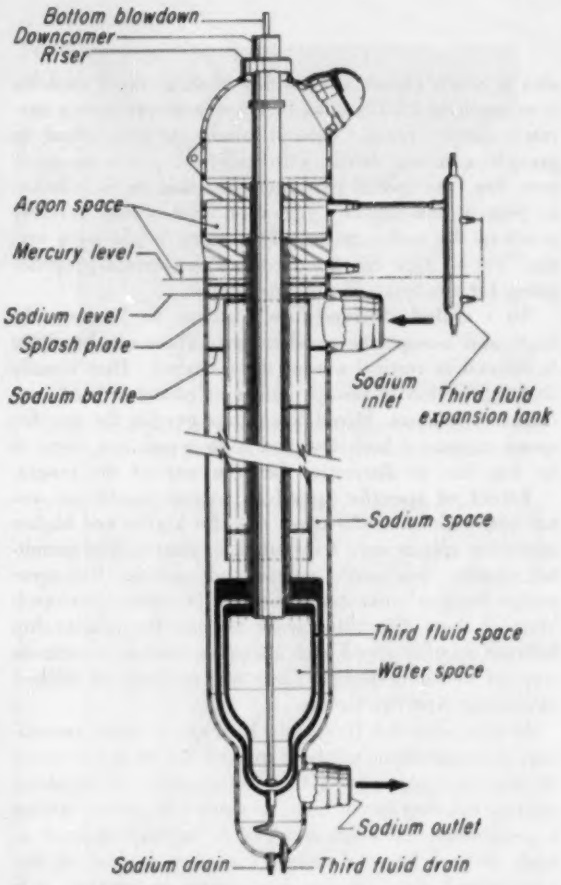
Standards of the Hydraulic Institute include centrifugal rotary and reciprocating pumps. Within each classification, sections cover nomenclature, hydraulic standards, test methods and installation and operating hints. Copies may be purchased from the Hydraulic Institute, 122 E 42nd St, New York 17, N. Y. Price for complete standards: $6.00 domestic, $6.50 foreign.

By J H AMMON and
T S SPRAGUE
The Babcock & Wilcox Company

With first development stages over, liquid-metal cooled steam generators appear ready to stand even tougher operating conditions as . . .

Liquid metals show new promise for nuclear plants

Newest designs include solutions



CURRENT DESIGN in dual-tube boilers uses straight tubes and special tube-sheet design. Argon gas provides shock-surge cushion

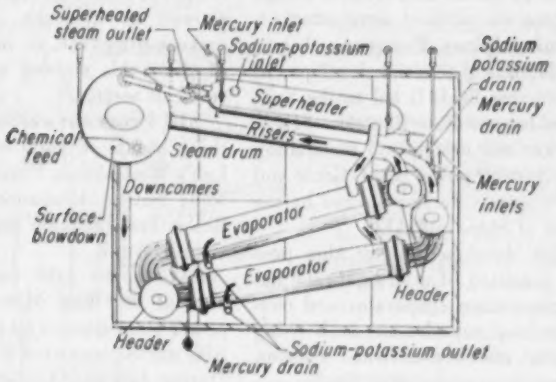
Over the last 13 years our country has spent millions of dollars and untold effort in basic research to develop practical nuclear-power reactors. Now, as commercial interest in power reactors begins to jell, we can step back and survey our accomplishments and their effect on future design. To help evaluate future nuclear-power installations, let's take a critical look at liquid-metal systems, past and future.

Liquid metals, particularly alkalies, are known for their excellent heat-transfer and transport characteristics. Preliminary investigations indicated several were technically feasible as reactor coolants. So much early work sponsored by AEC and the Navy centered on these materials. Major effort has been with sodium, but work has been carried out with sodium-potassium mixtures, bismuth (in Liquid Metal Fuel Reactor—LMFRE—program) and lithium.

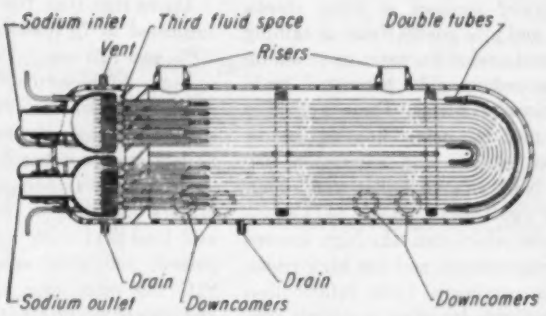
Alkali metals are widely accepted as reactor coolants for their same qualities of good heat transfer, low melting and high boiling temperatures, good thermal and radiation stability and low-neutron-absorption cross section. Since they are elementary substances, they will not decompose, polymerize or carbonize.

Design problems of generating steam with Na arose from our lack of knowledge of the basic operation. In some 12 years of laboratory development of fundamental technology, as well as proof testing model and prototype boilers, we have learned enough to define design criteria for alkali-metal-heated boilers with confidence.

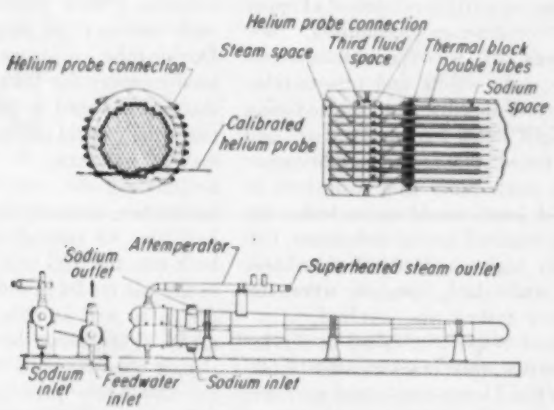
to operating problems of first units



GENIE PROGRAM produced first unit design based on boiler experience and ASME Boiler Code. Double concentric tubes carried Hg in annuli, ended in floating heads with thermal sleeves



SODIUM IN TUBES of SIG unit tested operation comparable to *Seawolf* generators. Double U-tube bundles were not sectionalized, used kidney sheets for inner tube attachments



ONCE-THROUGH U-tube U-shell unit carried sodium on shell side. Plugs at heads permitted tracing tube leaks with helium probes by draining system, pressurizing sodium side of shell

Let's consider some important problems and how they were met in specific designs. The principles apply generally to all alkali metals but our discussion stays with Na, involved in the majority of operating experience.

Chemical activity of sodium created design problems due to Na-H_2O reaction in the event of a leak. Since we cannot predict size and nature of all leaks and rate of Na dispersion, we can't fully evaluate the hazard. Theoretical analysis of reaction possibility, chemistry and mechanics is supported by shock-wave and bubble-energy research from which equipment-design recommendations have been made.

In several sodium-heated steam-generator development programs, boilers have been designed to use double concentric tubes. Mercury has been the third or "monitoring" fluid in the double-tube annulus of several of these generators. To avoid its toxic properties, the *Seawolf* boilers and model used NaK as the third fluid.

Tube leaks were simulated at Knolls Atomic Power Lab by injecting water directly into Na. Added research by Mine Safety Appliances Co, Babcock and Wilcox and others proved that fairly large water-to-annulus leaks could be spotted and action taken without undue mechanical damage.

There are three main reasons why little damage occurs: (1) Adequately designed gas-filled surge volume cushions and helps eliminate propagation of serious shock waves. (2) Properly designed sodium passages let flowing coolant carry away reaction heat rapidly. (3) Rate and degree of water dispersal into Na is slowed by oxide film on water droplets, plus isolating shield of H_2 gas generated by the reaction.

Other design problems related to chemical properties of Na are corrosion-leak detection and sodium-side cleaning, maintenance and repair. Specific designs, discussed in next pages, have tackled these problems.

Heat-transfer characteristics of liquid metals have not been fully defined. Several articles appear in the *Liquid Metals Handbook*, but designers must realize this area is not completely understood. A report by Mine Safety Appliances Co states liquid metals differ in heat transfer sufficiently to require proof-testing each new

configuration. The future looks brighter, for several programs in progress or considered should improve understanding of liquid-metal heat transfer.

Na becomes radioactive when passing through the reactor. This usually dictates use of intermediate heat exchangers to prevent water contamination. S1G and S2G *Seawolf* designs got around this by placing generators within the reactor-containment shield and steam separators outside, to separate systems, cut space and weight.

Materials of construction must be extremely pure. Powerful leaching action of liquid Na and K demands careful fabrication to avoid slag inclusions and oxide impurities—potential leak paths. Water side of double-tube systems in which the intermediate heat exchanger is omitted may need a material that resists pitting by oxygen released by radiolysis. Modern quality control, radiographic, dye penetrant and ultrasonic inspection catch most leaks. There is no known nondestructive test, however, which guarantees permanent leak-tightness—except extended operation under design conditions of temperatures and flow.

Thermal stress becomes a major design problem because Na's high thermal conductivity and film conductances can create severe thermal stresses at tube sheets, nozzles, etc, particularly during sudden flow or temperature transients. This calls for thermal blocks, sleeves, gas blankets, expansion loops and bellows.

An impressive array of functional and structural data has been assembled and many full-scale as well as model steam generators have been designed, built and tested. But there are still no positive design rules to guarantee satisfactory operation. It's still best to test a prototype or model.

First units tested basic theory plus design

Programs to investigate design concepts and evaluate for particular applications were started by AEC, Atomic Power Development Association, Sodium Reactor Experiment and others and carried out by various companies. Let's take a look at four of these programs and see how design problems we outlined were attacked.

Genie-Alphus Program, begun in 1947, was the initial development work in this field. It led to the Submarine Intermediate Reactor—SIR—Program and design and installation of the *Seawolf* power plant. Genie and SIR Programs were sponsored by the Bureau of Ships and AEC.

Boiler developed under this program consisted of a straight-tube natural-circulation evaporator and continuous-loop superheater, both using NaK - to - mercury - to - water systems, drawing on previous page. Design was largely based on prevailing boiler experience, ASME Boiler Code and the relatively meager data for Na and K available at that time.

Thermal stresses in tube sheets, heads and pipe connections containing NaK and cooled by water or steam on the secondary side presented main structural problems. These problems were met by using floating heads, thermal sleeves and expansion bellows. NaK side of boiler and superheater was 18-8 Cb (Type 347) stainless steel, which can take high stresses and temperatures and has high resistance to corrosion. Little information was available for other materials subjected to hot, flowing NaK. Boiler and superheater waterside tubes were of SA-280, 0.5% Chrome-Moly.

Double-tube generators of Genie-Alphus required development of many new construction techniques. New methods of welding stainless-steel plates, tube sheets and tube-to-tube-sheet attachments and of producing leaktight welds had to be developed and tested before final fabrication could start. Since slag inclusions in welded joints could cause leaks, the welds required special techniques. Unusually high standards of cleanliness were established, especially where the primary system was involved.

Upper evaporator failed in service by thermal stress cracking after 10,600 hours hot. Lower evaporator operated without incident. After removal from operation, an intensive metallographic examination was made of evaporator welds and areas where corrosion indications were found or suspected. Superheater was removed after some 4000 hours of operation, 3000 of them at 650 to 900 F. But examination showed no evidence of component corrosion by NaK or mercury. None of the welds showed cracking as a result of service.

SIR Program was subdivided into three parts: Knolls Atomic Power Lab's West Milton Program—(S1G), Mine Safety Appliance Co's Model Boiler Test Program and the *Seawolf* —(S2G) unit.

S1G boiler tube bank tested as part of the West Milton land-based power plant appears on previous page. S1G started operation in March 1955. During July and August 1955, steam-to-mercury leaks in both superheaters and one boiler were discovered. Leaks were small and their cause was never determined.

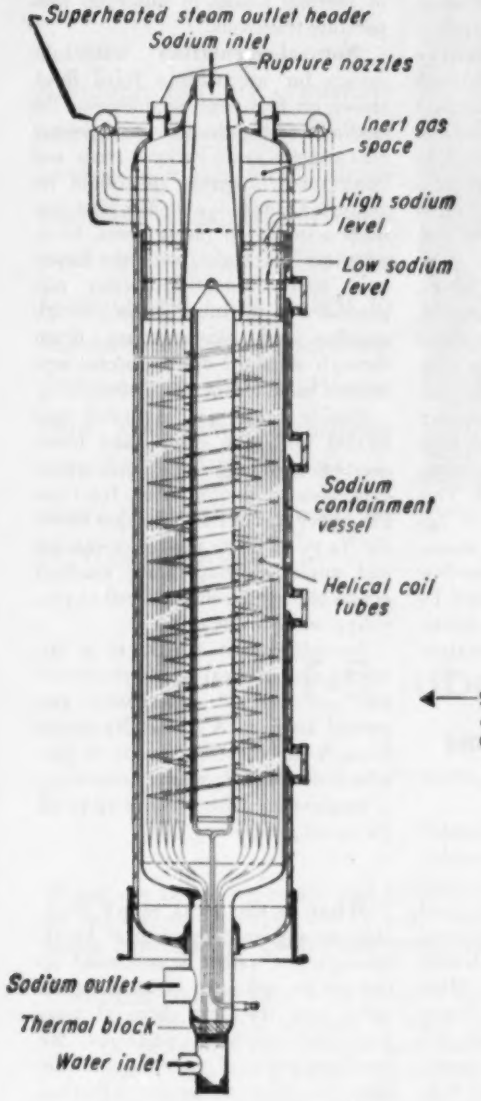
Up to that time the unit had been subjected to 79 load swings of 10 to 79% and 110 scheduled or accidental scrams. Nine occurred during high reactor-temperature differentials resulting in severe thermal shocking of boilers and superheaters.

Program was completed with generators operating at reduced pressure and load and with superheaters bypassed. Successful conclusion of the S1G test runs gave valuable design and operating information for double-tube sodium-heated steam-generating units developed in later programs.

Mine Safety Appliances Program evaporator was a natural-circulation U-tube double-tube design with mercury as monitoring fluid. Double-tube superheater originally used mercury for the third fluid, but this was changed to NaK so no mercury vapor could possibly get into the crew's quarters. A mercury-into-sodium leak also could have produced radioactive material of relatively long half life. All critical design features built into the S2G unit were included in the test model in order to prove its design as well as obtain information useful in operating the *Seawolf* plant.

Unit operated with NaK third fluid for 150 hours prior to superheater failure and 1667 hours before evaporator failure. During this time, it was subjected to 1125 maneuvering cycles (5% to 100% to 5% and 25% to 100% to 25%), 10 emergency cooling cycles and 46 occasions of severe carryover with up to 200-F steam-tem-

Containment, security dictate single- or double-tube-wall generators



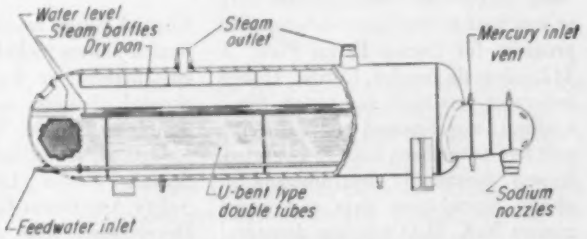
Evidence produced by development programs reassures designers that fairly large ruptures in single-wall tubes will not endanger operating personnel. Single-wall design, left, is based on assurance that all parts may be drained, vented and cleaned, and that no areas of stagnation exist on sodium or water sides. Inert-gas surge volume helps prevent damage by shock waves which might result from a leak.

This design illustrates single-tube-wall once-through generators with features including protection of containment-pressure shell from transient thermal shocks; pressure protection for shock-waves; ready access for inspection, cleaning and plugging; tube banks that can be removed from shell intact for inspection or maintenance; thermally protected tube joints in Na; no welds in the sodium other than shop butt welds in tubes. Basic configuration permits arranging surface to fit spiral-circulation and heat-transfer requirements of once-through boilers.

Double-tube unit, below, is "pot boiler" with Na inside tubes. New techniques bend double tubes in a single operation without resorting to low-melting-point metals which also pose cleaning problems. Twin tube sheets are employed with individual thermal sleeves formed in the tube annuli. An air annulus is formed around each sodium tube where it passes through the inner tube sheet, to protect sheet from thermal gradients.

Although the obvious economic advantages of single-wall designs have led to development of recirculated boilers and once-through units shown at left, efforts are continuing to improve double-wall designs like the pot boiler for applications where added safety of a monitoring fluid between liquid metal and water is considered necessary. For stationary units this added safeguard is less important.

◀—**SINGLE-TUBE** once-through design offers maximum operating safety, compact size of true one-through unit. Gas blanket, thermal shielding protect against transients



POT BOILER uses double tube wall with sodium inside tubes. New technique bends hard-alloy concentric tubes in one operation

perature drop in the superheater outlet. These test runs proved the structural adequacy of the boiler design.

Lab investigations of superheater confirmed that NaK introduced into superheated steam produces a very severe cracking agent which presumably could have caused superheater failure. Cracking was particularly prevalent in areas of severe fabrication stresses—from expanding, welding, forming, etc. Water carryover may also have accelerated failure of the superheater by thermal shock. And rapid cracking on the evaporator waterside could be caused by concentration of caustic introduced into the boiler water by a NaK leak. In addition, model-steam-generator tests highlighted design requirements necessary for readily cleaning and decontaminating pressure parts of Na-heated steam generating units.

Results of the model-boiler test program weren't ready until after fabrication of the *Seawolf* steam generator was essentially completed and so could not be used in its design. However, they were of great value in helping interpret operating experience

and guiding subsequent field modifications of the *Seawolf*.

***Seawolf*—S2G** developed cracking in the stainless-steel outlet piping shortly after superheater went into service. Investigation showed typical stress-corrosion cracking, probably caused by a NaK leak in the superheater. Leak cause could not be traced to material or welding defects in stainless components. Three more unrelated failures occurred in separate circuits of the starboard evaporator. Leak sources couldn't be pinpointed because of extensive stress-corrosion cracking of tube sheets.

Superheaters were bypassed and the unit operated at somewhat reduced load for 21 months without incident. Small tube clusters of S2G ended in inner and outer tube sheets at nozzles, so one cluster could be isolated with only 3 to 4% reduction in heating surface. The third fluid space between tube sheets connected to a surge tank which in turn joined a central monitoring system. A leak in Na, steam or third-fluid system would change pressure in the surge tank and provide a means for automatic leak detection.

Atomic Power Development Assn single-tube once-through boiler was part of the boiler-development program for Enrico Fermi Plant. A 1/125th-scale model U-tube U-shell generator was built and tested. Since a liquid-metal-heated once-through unit had never been built or operated, it was thoroughly instrumented to obtain temperature data and guard against NaK- H_2O reaction damage.

Extensive testing over 15 months subjected the unit to varying steady-state and transient operations. It successfully withstood 40 normal and 25 forced shutdowns, including eight scrams caused by control malfunctions, weather and power interruptions. Neither liquid-metal system nor once-through boiler was responsible for any unscheduled outages.

Unit weathered 150 transient tests. Coupled with shutdowns, this comes out to many times the cycling expected in equivalent length of normal operation. During 4200-hours accumulated operation no mechanical weaknesses showed up. These tests demonstrated the practicality of once-through single-walled steam generators, from both functional and structural aspects of the overall design.

Sodium Reactor Experiment—SRE program included a once-through U-tube U-shell unit designed and built by Babcock and Wilcox, installed and operated by Southern California Edison Company. Boiler contains concentric double-wall stainless tubes with mercury in the annulus and sodium on the shell side.

To cut Na circulating-pump power, no shell-side baffling was installed. High Na conductivity was expected to insure uniform temperature profiles across the 24-in. ID shell. Initial operation, however, indicated a large temperature unbalance with higher-temperature Na flowing along the shell top for its entire length. This helped cause and in turn was aggravated by water-flow and steam-temperature unbalances. Water-flow unbalance was largely eliminated by installation of orifices in tube inlets, greatly reducing Na-side temperature stratification in this design.

Future progress stems from tested theory

Current design trends in liquid-metal-heated boilers include both recirculated (natural or forced) and once-through boilers, both single- and double-wall tubes. Experimental and analytical investigations by Knolls Atomic Power Laboratory, Mine Safety Appliances Co, Atomic Power Development Assn and Babcock and Wilcox provide considerable assurance that even fairly large tube ruptures in single-tube steam generators will not endanger operating personnel.

Single-wall design is illustrated by the once-through unit on previous page. All development work and lessons learned in operation of the APDA and SRE units have been incorporated into designs of this type. Unit shown is not the only current solution to these problems, but is representative of general design thinking for single-tube-wall units.

Double-wall designs appear with liquid metal in tubes or on the shell side. "Pot-boiler" unit, previous page, represents latest advances in fabrication procedures for dual tubes and use of thermal blocks to minimize temperature transients.

Natural-circulation water-tube design for use with a third fluid, shown on first page, supplements the pot boiler. Straight-tube arrangement cuts annulus space between inner and outer tubes, lowering third-fluid inventory. Central downcomer pipe connects a steam-separating drum, located above the boiler, with the lowermost tube sheet. Steam-water mix generated in the tubes leaves through annulus and enters steam drum through standard cyclone steam separators mounted in the drum.

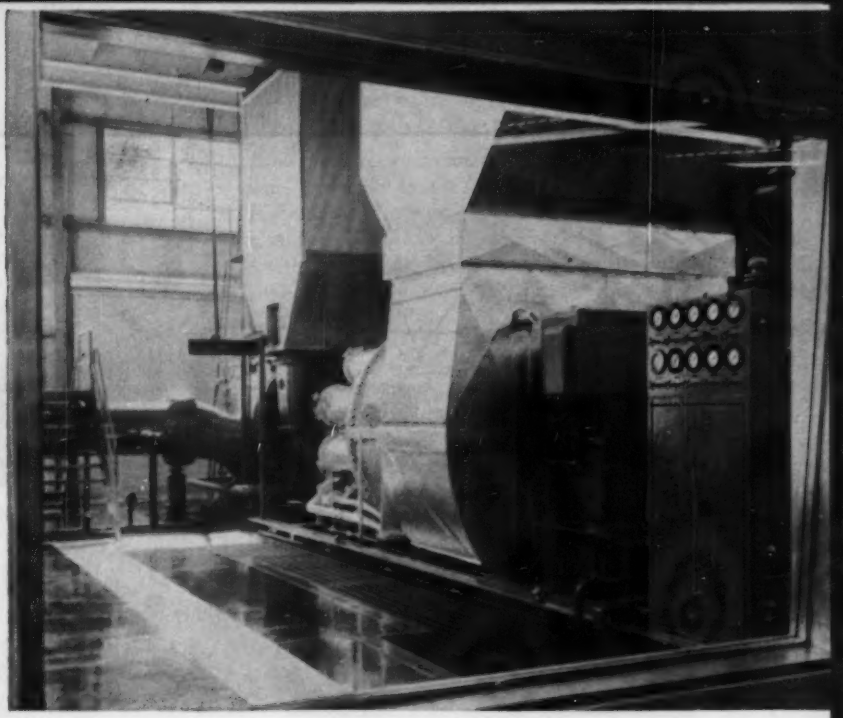
Double tubes are expanded and welded into tube sheets, and lower sheets float to take care of differential expansions in double tubes. Inert gas fills upper part of the exchanger above the Na to act as an insulating blanket and minimize temperature gradient across upper tube sheet as well as providing surge volume.

Assembled unit consists of a battery of four vertical steam generators and one vertical superheater suspended from an A frame. Na passes through superheater, then on to parallel flow through steam generators. A single steam drum connects to all the steam generators.

What is the next step? Probably no sudden technological breakthrough, but rather a continued attack on the unknown areas of liquid-metal heat transfer, chemical reactions and corrosion problems. We now have practical operating units designed to withstand the severe thermal stresses of liquid-metal systems and are continuing to trim the bulk of overall steam-generator systems. In general design we have reached a point where we can concentrate on refining several workable systems to deliver optimum performance for minimum cost. As in conventional steam-generator design, much effort will go into newer and better basic designs at the same time that proved designs are refined.

Looking forward, we see we've now reached the point where the liquid-metal-cooled power reactor is no longer a pure research project, but a power source to be reckoned with.

Although the fire-resistant lubricants have seen limited service in mechanical-drive steam turbines and air compressors, Texas Eastern Transmission Corp is first to use synthetic lube in pipeline-pumping gas turbine. Here is their operating experience with the fluid in form of answers to questions posed by POWER editors as . . .



TURBINE ROOM houses gas turbine, controls in foreground, load compressor far end

F-R lube proves out in gas turbines

By O M FLETCHER, Asst Supervisor, Design and Construction, Texas Eastern Transmission Corp

What are the more significant technical factors to be considered prior to use of a fire-resistant synthetic lubricant in gas-turbine pumping units?

Fluid must be capable of properly lubricating all parts involved in addition to being fire resistant. On latter score the lubricant must not flash or support combustion if accidentally exposed to hot turbine parts operating between 700 and 1000 F. Naturally, highest order of protection would be had if the fluid could remain fire-resistant at the full combustion temperature, about 1425 F.

Being a suitable hydrodynamic, hydrostatic and boundary lubricant is a measure of fluid's lubricating ability. In a gas turbine it also must perform well as a hydraulic-control medium, a liquid sealant and coolant. Part-by-part analysis is a must to pin down the theoretical action of parts exposed to the synthetic lubricant. This means a study of . . .

1. Main, auxiliary journal and thrust bearings in addition to couplings and gearing for fluid's ability to lubricate, cool and carry load without excessive losses.

2. Control and relief valves, orifices and piping for proper performance.

3. Oil pumps for correct supply and scavenging characteristics and for hp-input requirements.

4. Heat exchangers in light of the synthetic's thermal and density characteristics.

5. Filters for ability to clean the stream without excessive pressure drops and without altering the fluid's physical and chemical properties.

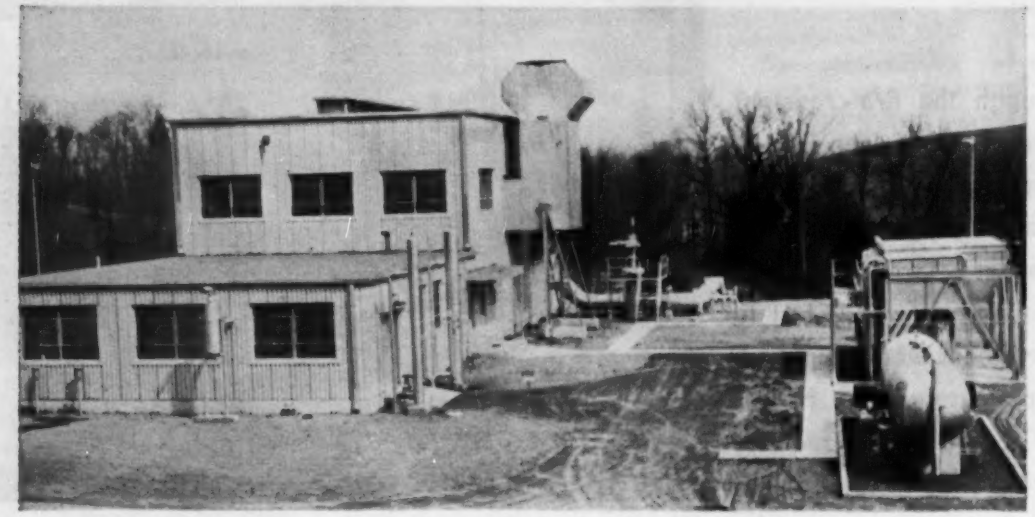
6. Seals, gaskets, diaphragms, paints, coatings, thread compounds and filter materials for chemical compatibility with the oil.

Also consider possible contamination of the fluid through normal exposure to methane load gas and change in fluid characteristics from normal use.

What laboratory tests do you suggest be conducted on a proposed synthetic fluid before acceptance?

Available commercial fluids have already been extensively lab tested by both makers and potential users. However, the tests are just that—lab or bench tests. There is a marked lack of data on full-scale bearings, couplings, gearing heat exchangers.

Naturally, there is ample lab data covering fire resistance, wear and general characteristics. Included are data on viscosity, density, specific heat,



TYPICAL REMOTE STATION has insulated lube-storage tank, right, with water-to-air heat exchanger immediately behind

Pipeline pumping success may spark new interest in F-R lubes

Four remotely controlled unattended pumping stations on one of the Texas Eastern pipelines in Pennsylvania have successfully used a synthetic fire-resistant phosphate-ester type fluid as the lubricant in their gas-turbine drive and centrifugal pipeline compressor. Representing a total of 53,600 hp, these remotely controlled stations are alternated between manned gas-turbine stations, each remote controlled by its adjacent downstream manned station.

Stations went into service Oct 1958. Each is designed around a GE simple-cycle single-shaft 13,400-hp gas turbine directly connected to a Clark Bros 30x30-in. 2-stage centrifugal compressor rated 730M² scfd. Turbine oil system supplies load compressor needs plus those of turbine. In normal operation the synthetic Monsanto Chemical Co lube is pumped from reservoir through a series of filters to an oil-to-water heat exchanger, to the turbine and compressor, then dumped back into reservoir. Makeup oil is supplied from an external tank.

neutralization value, water content, flash and fire points, foam and oxidation values, autogenous and spontaneous ignition temperatures and toxicity data. Until full-scale tests or more operating data are available, present testing is primarily concerned with compatability and fluid stability.

Recognize that despite all precautions, some incompatible materials will be used. So tests are necessary to establish the effect, on both the fluid and the material, of various mixtures of possible contaminants such as paints, sealants, etc. Fluid must be tolerant to reasonable quantities of such materials. At present we feel there are no tank or paint coatings in use long enough to establish compatibility; these answers will come with time.

Considerable lab work has been done to determine effect of the synthetics within uncoated oil tanks. Present lab practices depend on extrapolation for any such answers. These tests indicate that oil tanks and the oil therein, in a moisture-saturated atmosphere, show no harmful effects on fluid stability or tank surfaces. Reasonable extrapolation of test data indicates this condition will hold for upward of five years from time of installation.

What design changes are necessary in the gas-turbine units for successful operation with synthetics?

No design changes were necessary in any of the oil-associated parts, except as related to compati-

bility or fluid low-temperature viscosity. As would be expected, there was considerable substitution of gaskets, thread compounds, O rings, seals, etc. All paint was removed from areas exposed to the oil. Since complete paint removal was impractical in inaccessible areas, additional filtering was incorporated in control and seal-oil systems.

Oustide oil-to-air heat exchange is not feasible with a high-pour-point fluid (oils with p-p above zero F). Practical answer is to make an inside water heat exchange and have an outside water-to-air unit. This means adding a complete water-cooling system. Furthermore, high-pour-point oils require auxiliary heating if stored and carried outdoors. Likewise the gas-turbine oil system must hold a minimum temperature of about 70 F even when not operating.

Experience with the phosphate-ester type fluids raises the question of harmful effect on electrical insulation. On this score the gas turbine has but one point of exposure: the tachometer generator. Application of epoxy-resin coatings to these windings, without further modification, has proved successful thus far.

Does experience indicate the phosphate-ester fluids will carry off heat as effectively as petroleum oils? Do they lubricate as well?

Our operating experience is with equipment designed for heat transfer using petroleum oil as the medium. Both turbine and compressor design is based on oil having a specific heat of 0.5 and a specific gravity of 0.85. So using the phosphate ester with a 0.34 specific heat and a gravity of 1.38, we wind up with a slightly better overall heat-transfer rate on a Btu/unit volume/degree basis. On a volume basis, the synthetics have between 2 and 5% better heat transfer than petroleum oil.

In light of the somewhat higher Saybolt viscosity of the synthetic, filter-fluid pressures were raised between five and eight psi to compensate for possible plugging. Actually, filter plugging has not occurred and pressure drops across the filter closely followed calculations.

Comparative calculations for the phosphate ester and petroleum indicate journal-bearing hp losses could be 15% higher when using the synthetic, 10% higher for thrust bearings. Temperature rise in both bearings was calculated to be about 35 F for either petroleum or synthetic with a 175-F maximum operating temperature figured for both fluids. However, the gas-turbine units were never operated with petroleum so an actual comparison was not made. Calculations indicate journal bearings and unloaded thrust bearings show an average 4- to 6-F higher temperature rise compared to petroleum.

To date there have been no major bearing failures and, after 3500 hr, inspection of some 75% of all bearings in each machine shows them to be in excellent shape. Minor bearing failures which have occurred have all been from the usual causes: foreign matter or faulty bearing materials.

What have been operating problems to date?

After nearly two years there have been no problems traceable to the synthetic. During the first few months of operation, two of the four units had a number of minor outages caused by failure of a small worm-gear drive in the turbine accessory gear. This drive consisted of a steel worm driving a bronze gear and loaded to about 13 hp: the bronze gear wore. Time ruled out an extensive investigation but we reduced load on drive, provided for more-positive lubrication, changed bronze gear material and improved alignment, and the trouble disappeared. There was no definite indication that the fluid was a prime cause of the trouble.

When installed, the water-white phosphate-ester fluid was colored with an inorganic red dye as an aid in gaging flows and oil levels. For some unknown reason the dye darkened considerably while the fluid remained on specification. Since there was no change in the synthetic oil, merely a change in the dye, there was no cause for concern.

Does Texas Eastern plan to use synthetic F-R lubricants in future stations?

Considering the success to date, we would not hesitate where conditions warranted an F-R lube. Basic criteria would be investment protection in a remotely controlled unattended turbine installation. An added thought: there is strong indication that some forms of the phosphate-ester fluids could be used successfully in large i-c engines, if needed.

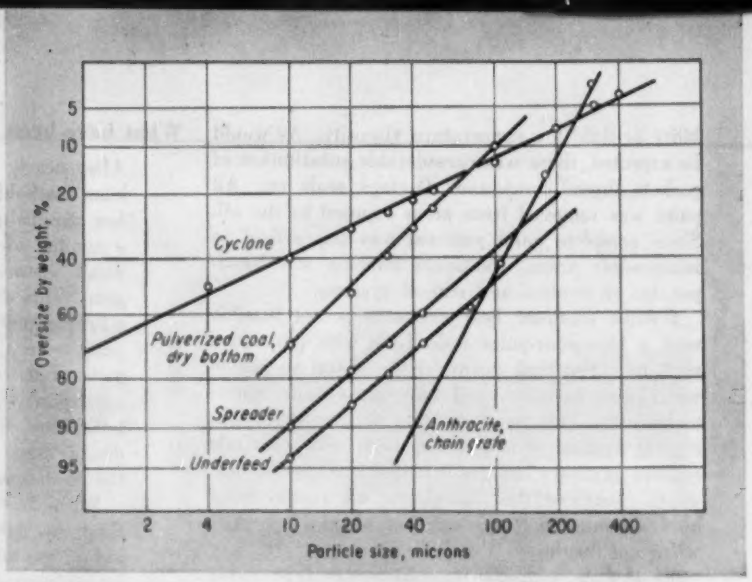
Are present tests and standards used for synthetics adequate and suitable?

In recent years F-R lubes have seen service in gas turbines, steam turbines and air compressors. Forms of the phosphate-ester fluids, either the pure ester type or a chlorinated version, were used. What tests and standards are used to evaluate these fluids?

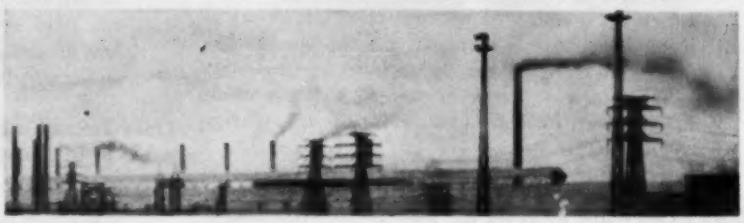
Present practice is to use the ASTM tests, designed originally for petroleum oil. The results of some of these tests are either not applicable, meaningless or of doubtful value when the tests are used for a synthetic. Notably missing are standard tests for fire resistance. Actually, F-R ability seems well covered by numerous tests used by the fluid manufacturers. Nevertheless, there are no standard tests available.

Wear tests and extreme-pressure (EP) tests, although designed primarily for petroleum oil, certainly give an indication of what may be expected from a given lubricant. There is a shortage of tests designed specifically to evaluate gear-system lubricant during field operation.

EDITOR'S NOTE: *The first full field test with a synthetic lube in the bearings and control system of a steam turbine driving a boiler-feed pump at Consolidated Edison was reported in* POWER, *March 1955. Commonwealth Edison and Duquesne Light have also conducted tests* (POWER, *May '58*).



PARTICLE-SIZE distribution of flyash follows so-called *log-probability law*. Ash from suspension firing is finer than that from partial-suspension or fuel-bed firing



PLUME OPACITY increases as particle size decreases. It's for this reason that removal of +20-micron particles has little effect on the appearance of a plume

Last month we discussed fuel characteristics and their effect on air pollution. Now let's take a look at how specific industrial boiler designs affect the . . .

Formation of air pollutants

By GREGORY GOULD, President, Fuel Engineering Co of N. Y.

In the early days of the industrial revolution, hand firing of coal and natural draft were the distinguishing features of our steam-generation methods. Firing-equipment development, still continuing, has produced a variety of mechanical contrivances for firing coal. Advent of oil and gas as competitive fuels demanded special combustion equipment. Thus we have diverse equipment types, operating methods, boiler and furnace designs and load demands, all influencing in varying ways and to varying degrees the quantities and characteristics of air pollutants which are formed.

There are no universally accepted designs for stokers, furnaces and boilers, although heat-release rates and furnace-setting heights are commonly considered. High heat-release rates are generally accompanied by excessive flyash, cinder carryover and sometimes smoke. In fact, smoke is the most common sign that release-rate limitations are exceeded.

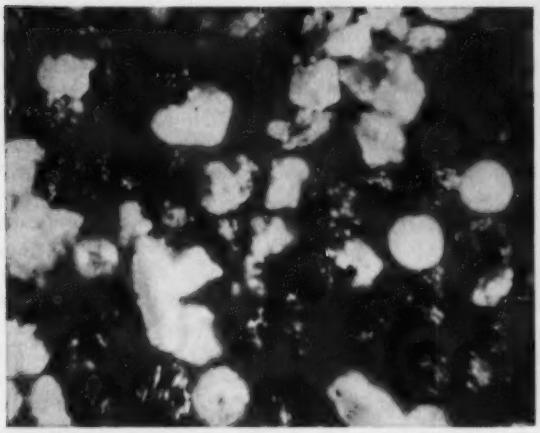
A Bureau of Mines study of 22 smoke-abatement ordinances revealed wide variation in requirements for similar equipment types under similar operating conditions. Maximum heat release, Btu per cu ft per hr, ranged from 33,000 to 65,000 for underfeed stokers, 16,660 to 45,000 with pulverized coal and 22,300 to 45,000 with heavy oil.

Load variations can create problems. Sudden demand changes may exceed equipment's ability to respond, produce smoke at times. Too, dust accumulated in long runs of horizontal breeching during low-load periods may suddenly re-entrain, producing puffs from the stack. Overfilling dust-collector hoppers can cause difficulty, result in less than zero collection efficiency from the unit involved as dust becomes re-entrained in gas stream and is carried to the stack.

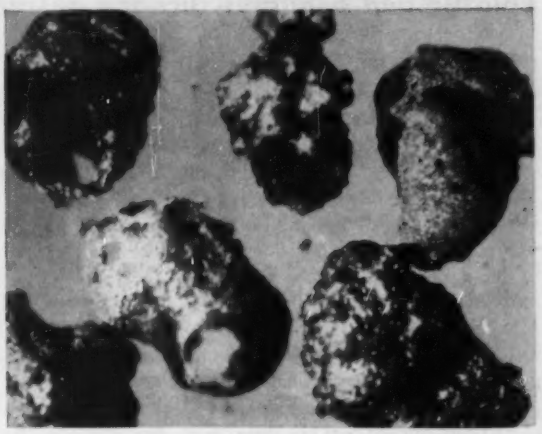
Stoker firing is really a whole family of different firing methods, each with problems peculiar to the stoker type. Example: traveling-grate stokers don't agitate the fuel bed. Thus they're not as readily adapted to high-caking coals as stokers using grate motion to break up coke masses and keep fuel bed porous.

Special designs handle anthracite, which has a lower ignition rate than

Flyash-particle size significantly affects collection efficiencies



DIFFERENT-SIZED PARTICLES in flue dust may show significant characteristic variations. Particles ranging in size from under 20 to 40 microns, above, tend to form stable agglomerates adhering to surfaces. This finer ash is apt to plug centrifugal collectors, and the finer particles are hard to dislodge from the collecting plates of electrostatic precipitators. They cause efficiency dropoff



SPECIFIC GRAVITY of flyash is related to size of particles as well as their structure and carbon content. Larger particles which tend to run high in carbon usually have densities less than 1. Finer particles will have densities from 1.5 to 3, while very small particles may run well over 4. This large variation in density can often produce stratification of the dust in flue-gas streams

bituminous. Ignition is promoted by increasing amount of radiant heat reflected from furnace refractory to incoming fuel. Arches used for this usually cut furnace volume below that required for bituminous, so anthracite and bituminous generally can't substitute for each other as alternate fuels.

It's common to offset slow anthracite ignition rate by increasing draft through rear section of grate to point where incandescent fuel is lifted from the fuel bed and deposited on incoming fuel. While this practice is effective, it puts some fuel into suspension and finer particles tend to ride out of the boiler in the gas stream, increasing flyash emission.

Large traveling-grate stokers with high combustion rates may use reinjection of high-carbon cinders from the boiler's afterpasses. This, too, increases emission rates from the chimney. Quantity of flyash and cinders rises both with higher combustion rates and greater proportion of fines in the coal. With anthracite, combustion rates in excess of 25 lb per sq ft per hr are likely to exceed ASME model-code limit of 0.85-lb dust per 1000-lb flue gas.

Typically, over 50% of flyash from traveling-grate stokers burning No. 3 buckwheat coal will be larger than 100 microns, and very little under ten microns. The same is true when burning bituminous coal except that quantity of −10-micron material may run from 10 to 20%.

Vibrating-grate stokers, introduced in this country in the past ten years, aren't yet too widely known. Rear arches have been found desirable to cause gases from the rear portion to sweep forward and ignite volatile distilled over the forward section. Overfire air jets prevent smoke. Available evidence suggests that the ASME model-code dust requirement may be achieved at grate heat-release rates under 450,000 Btu per sq ft per hr.

Single-retort underfeed stokers, seldom used under boiler capacity of more than 30,000 lb per hr, are generally sensitive to coal quality at combustion rates above 25 lb per sq ft per hr, or about 325,000 Btu per sq ft per hr. The rather thick fuel bed makes coal sizing and ash-softening temperature critical factors. For this reason, clinker troubles often arise at combustion rates above 25 lb per sq ft per hr. Clinkers usually demand hand working the fire and this inevitably results in smoke.

Multiple-retort underfeed stokers are widely used up to 100,000-lb-per-hr steam capacity; a few go up to 200,000 lb per hr. Combustion rates may be as high as 675,000 Btu per sq ft per hr under favorable conditions. But at high combustion rates flyash carryover will be objectionable if collectors aren't used. For optimum operation, furnace heat-release rates shouldn't exceed about 35,000 Btu per sq ft per hr. Since segregation of coarse and fine coal sizes tends to create blow holes in the fuel bed and manual efforts to cover them may cause smoke, coal should be delivered to the stoker hopper unsegregated.

Excessive fines cause localized high combustion rates which produce cinder and flyash carryover. Reducing quantity of −¼-in. coal cuts stack emission in many cases. Not more than 50% of the coal should pass a ¼-in. screen. Particulate emissions from underfeed stokers in general parallel figures quoted above for traveling-grate stokers.

Investigations show from 5 to 30% of the ash may leave underfeed-stoker-fired furnaces—the upper range can mean as much as 5½ lb of dust per 1000 lb of flue gas. Typical size dis-

Dust loading is a function of coal's size, volatile and ash, plus furnace design

tribution shows 50% exceeding 100 microns, less than 10% under 10.

Spreader stokers, popular with boilers from 15,000 to 100,000 lb of steam per hr, have burned both Midwestern free-burning and the caking Eastern coals. But without collectors stack emission is almost sure to be a problem because fines are burned in suspension. Theoretically, particles of 500 to 600 microns remain suspended in the upward-moving gases at high combustion rates. As a practical matter, even larger particles of partially burned coal are entrained.

Very-thin fuel bed results from fuel burning almost as fast as it's fed into the furnace. This design responds quickly, smokes immediately if fuel-air ratio isn't adjusted properly. Automatic combustion controls are essential if violation of air-pollution ordinances is to be avoided.

The spreader stoker tends to smoke both at very high and low loads. Under 25% capacity, cold furnace conditions usually cause the smoke. At high loads unbalanced fuel-air ratios are likely to result from aerodynamic limitations of the grates. Most satisfactory performance is expected at 3-to-1 turndown ratio. Steam jets or preferably high-pressure air jets increase turbulence over the fire—essential for optimum performance in this range.

Flyash emission is significantly affected by amount of −⅛-in. sized coal. Some coals specifically prepared for spreader stokers have virtually all the −⅛ size removed. But size specs usually permit up to 50% −¼-in. with ¾- to 1½-in. top size.

It has been estimated that between 20 and 40% of the ash leaves the furnace with spreader-stoker firing. Actual emission rates range from less than 0.85- to as much as 10-lb dust per 1000-lb flue gas. Typical size distribution of this flyash will run 50% greater than 50 microns and 10 to 20% less than 10 microns.

Cinder reinjection, used almost universally with spreader stokers, ups stack emission. Total reinjection may increase gas dust loadings 50% or more over no reinjection. Partial reinjection increases emission, but the effect is not so pronounced. With total reinjection, collector efficiency of about 94%, with partial reinjection an efficiency of 90% meets most air-pollution-control ordinances.

Pulverized-coal firing, used most often with boiler capacities exceeding 50,000 lb per hr, makes duct-collection equipment mandatory. High dust loadings are normal since all fuel is burned in suspension.

Dust loadings are a function of furnace type, the coal's pulverized fineness, volatile and ash content. In wet-bottom furnaces as much as 50% of the ash may be trapped within the furnace; in dry-bottom units trapped ash runs from 25% down to less than 10%. Dust loadings range between 3 and 12 lb per 1000 lb of gas.

Size consist of flyash from pulverized-coal furnaces is influenced by fineness to which coal is originally pulverized and to some extent by pulverizer and furnace types. Coarse flyash is typically 50% larger than 20 microns and 30% smaller than 10 microns. Fine flyash may contain as much as 65% of −10 microns.

Cyclone-burner firing uses coal crushed to pass a 4-mesh sieve introduced tangentially under high air pressure into a cylindrical combustion chamber. Circular motion throws the coal to the periphery where it is swept by high-velocity air and burned at such high rates that the melting temperature of many coal ashes is exceeded. From 80 to 85% of the ash content of suitable coals never reaches the combustion gases. Instead, it melts and is continuously tapped off. Ash that does become entrained in the gas stream is extremely fine, 70 to 90% being less than 10 microns. This fine dust causes a characteristic brownish plume from cyclone-fired-boiler stacks. The cyclone furnace operates with a minimum of excess air. As a result, flyash may be present in concentrations as high as 2½ lb of dust per 1000 lb of gas.

Firing heavy oil has its own problems. The oil burner's job is to atomize the oil and mix it thoroughly with proper amount of air. If atomization isn't fine enough, smoke and soot form and are carried out the stack. Rich fuel-air ratios favor carbon formation so it's important to maintain proper excess air at all loads.

Viscosity and surface tension play important parts in atomization. Since heavy-fuel-oil viscosity changes rapidly with temperature, minimum at which each type of burner performs its atomizing function properly is quite critical. Even with good combustion, opacity of plume may exceed a No.-2 Ringelmann smoke shade.

Particulates loading from oil-fired equipment is quite low: the Los Angeles Air Pollution Control District's testing program showed an average of 0.14-lb dust per 1000-lb gas. Tests conducted by a West Coast utility reveal that as little as 3-ppm SO_3 in the flue gases produces a visible plume, 15 ppm a conspicuous one. The utility found that presence of normal particulates from an oil-fired unit increases the opacity of these plumes by about 50%.

Importance of nitrogen oxides in the air has recently come to the fore as knowledge of photochemical smogs advances. Industrial stacks are one source of nitrogen oxides. Available evidence indicates that actual nitrogen content of the fuel has little effect on quantities of nitrogen oxides in flue gases. Apparently the nitrogen source is in the combustion air. Tests conducted at a prominent boiler manufacturer's research center disclosed nitrogen-oxide concentrations ranging from 310 to 915 ppm in the flue gases of oil-fired boilers. Where boilers were tested with more than one fuel, relative concentrations were about the same for both fuels.

The "2-stage combustion" technique shows promise for reducing oxides of nitrogen produced by an industrial boiler. In this method, less than theoretical air for combustion is introduced at the burner. Remaining air is brought through auxiliary ports so it reaches the flame *beyond* the small high-temperature zone where nitrogen oxide forms. This arrangement produces a more-protracted flame path which can alter furnace conditions somewhat.

Gas-fired equipment's particulates emission is not likely to be a matter of consequence. If a nitrogen-oxide-hydrocarbon smog problem is involved, however, quantities of nitrogen oxide which may be produced could be a matter of concern. Tests have shown nitrogen-oxide concentrations from 200 to over 1000 ppm.

Planning underground distribution? Recent installation demonstrates modern methods, shows that . . .

Precast manholes save man-hours

By JOHN C KACHARIAN*
Watervliet Arsenal

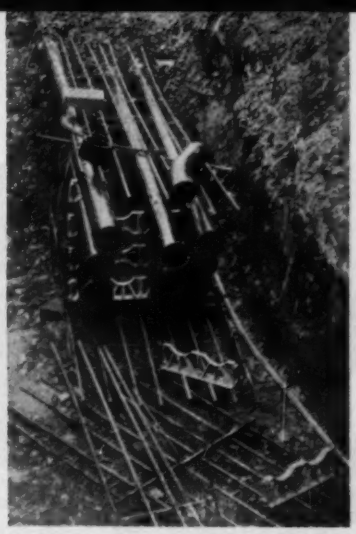
Complete modernization of exterior electrical-distribution system at Watervliet Arsenal is under way to provide adequate, efficient facilities. Arsenal, commanded by Col. Walter M Tisdale, is Army Ordnance Corps center for research, development, engineering and prototype manufacture of cannon, and re-engineering facility for missile components.

Eighty concrete manholes in three sizes were precast, saving about 80 man-hours. The power manholes are 8x8x6 ft, with either 1½- or 3-ft clipped corners; communication manholes are 4x8x6 ft with 1½-ft corners. Duct system consists of four to twenty 4-in. fiber conduits and fittings encased in concrete. Conduit joints were swabbed with bituminous waterproofing before attaching couplings. Top of concrete is minimum of two feet below surface (four feet under railroad) — horizontal holes were bored under railroad tracks. Longest run is 90 feet through shale.

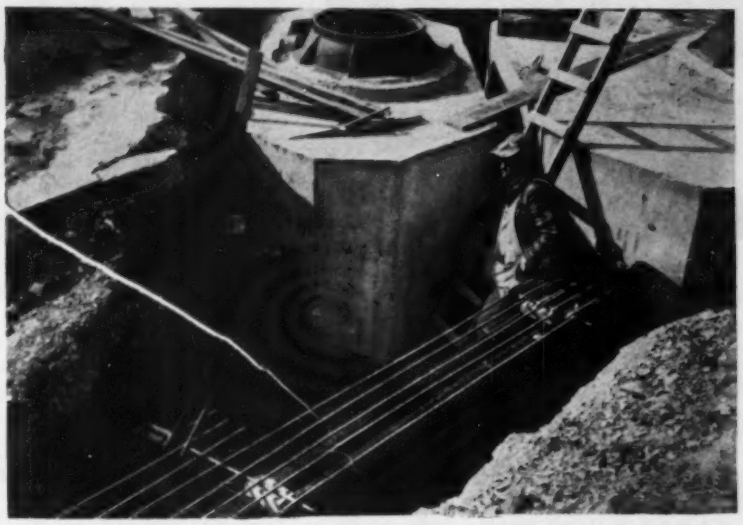
Present project is contracted for $2,036,000, and is under administration and supervision of Col C M Duke, District Engineer, N. Y. District, Corps of Engineers. C Roe is Resident Engineer. Arsenal coordination is effected by Lt Col J G Short, Post Engineer, and the author. Contractor is Nager Electric Co, Inc.

*J C Kacharian is Chief of the Engineering Section of the Post Engineer's Office at Watervliet Arsenal, Watervliet, N. Y.

BORING for precast interlocking duct section didn't interfere with railroad operation

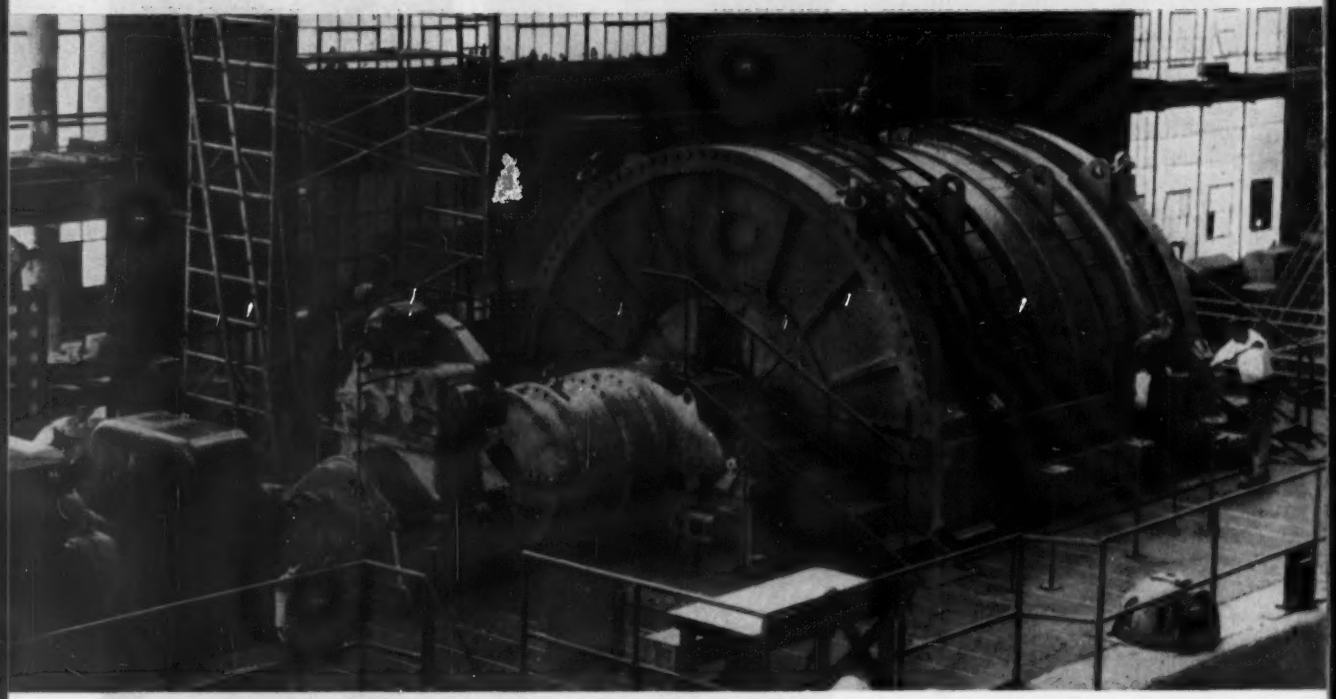


PLASTIC BLOCKS space conduit properly and anchors hold it while concrete is poured



PRECAST MANHOLES were set on poured-in-place bases by crane. Manhole fits into base keyway which has premolded filler strip. Joints are caulked with waterproof compound

POURED CONCRETE encases ductwork and seals manhole openings where ducts enter the clipped corners. Concrete was steel-rod reinforced in ductwork under roads and paving



1 Turbine-spindle test facility with the 1800-rpm heater box in position. Driving turbine rated 6000 hp at 4320 rpm, left, turns spindle in box. A 1500-hp reverse turbine, hooked up in tandem, brakes spindle to a quick stop if vibrations get out of hand

Spindle test raises turbine reliability

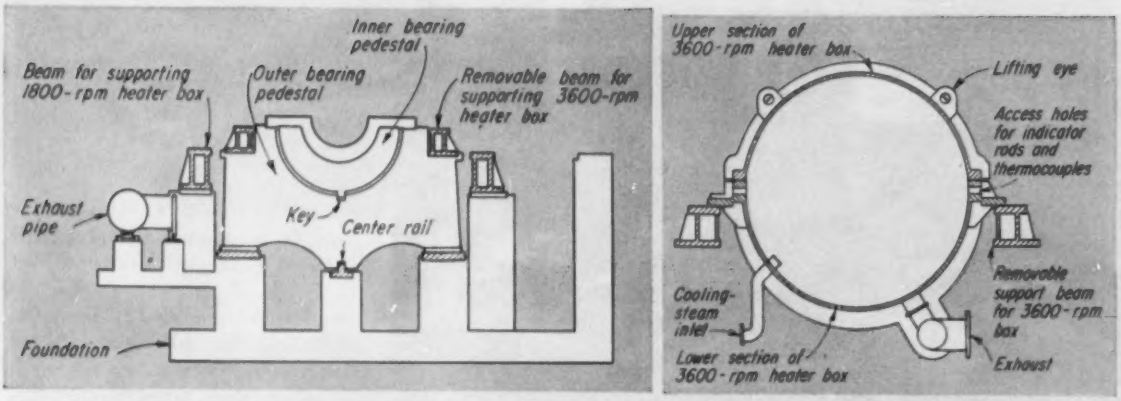
Testing spindles of modern steam turbines before delivery for balance and vibration uses specialized equipment. This apparatus helps find and solve stability problems before they have a chance to develop in the field

By A F LeBRETON, Steam Div, Westinghouse Electric Corporation

Low level of spindle vibration proves an important contribution to steam-turbine operating reliability. Balancing the spindle in the shop, after machining and blading, aids early installation in the plant. Occasional stability problems associated with balancing need extended processing that can be done in the shop and not conveniently in the generating plant.

Extended spindle processing may be needed to achieve final balance because of slow changes in balance caused by higher steam temperatures in modern turbines. Extended test runs at 3600 rpm use highest temperatures that the spindle will experience during its service. If no changes in amplitude or phase angle of the spindle vibration are observed during the test run, spindle is given its final balance, then it is shipped.

If vibration amplitude or phase angle keeps changing at operating temperature, speed is dropped to about 30 rpm and the spindle temperature raised about 150 F over the maximum operating temperature. These conditions are held for a period controlled by metallurgical considerations.



2 Heater-box layout is designed to accommodate spindles in a wide variety of lengths and diameters. Reinforced-concrete foundation carries center rail to align the bearing pedestals and heater-box shell sections. Beams support the shell sections

After completing the soaking period, spindle again runs at its operating speed and temperature. If spindle vibration remains constant for an extended period, it gets its final balancing and is shipped. If vibration still varies, the spindle goes through another soaking sequence until it proves out.

All turbine spindles are tested for a short time at 120% of normal running speed. The high centrifugal stresses seat attached parts and allow correcting any unbalance.

Turbine cylinders are shipped to the power plant before the spindles. They can be erected while the spindles are under test, sometimes advancing unit's starting date.

The facility also tests blades, shrouds, lashing wires and separate disks before they are designed into a complete machine. This insures adequate design of the larger blades, which have grown much longer during the past few years.

Foundation for the heater box is made of reinforced concrete, Fig. 2. A center rail runs the length of the foundation to align all components of the heater box: bearing pedestals and shell sections.

Steel ways running full length of the foundation sides have a seating surface for the bearing pedestals, and the pedestals can slide along these ways as needed. Concrete columns at foundation corners support two fabricated beams, which in turn carry shell sections of the 1800-rpm heater box. Three reinforced-concrete piers at one end of the foundation support drive turbines for the spindles.

Bearings nearly identical to those used in the complete unit support the spindles being tested. Support rings hold bearings for 3600-rpm spindles. An inner bearing pedestal carries the support rings, and holds 1800-rpm-spindle bearings directly. Liners are used as needed. These arrangements handle all the different-sized bearings now being used and those contemplated for the next ten years.

Inner bearing pedestal is a curved cast-steel beam supported at its ends. An electric motor driving two lead screws moves this piece in an axial direction relative to the outer pedestal. Automatically controlled movement allows for longitudinal thermal expansion of the spindle—at high temperature it may expand as much as one inch.

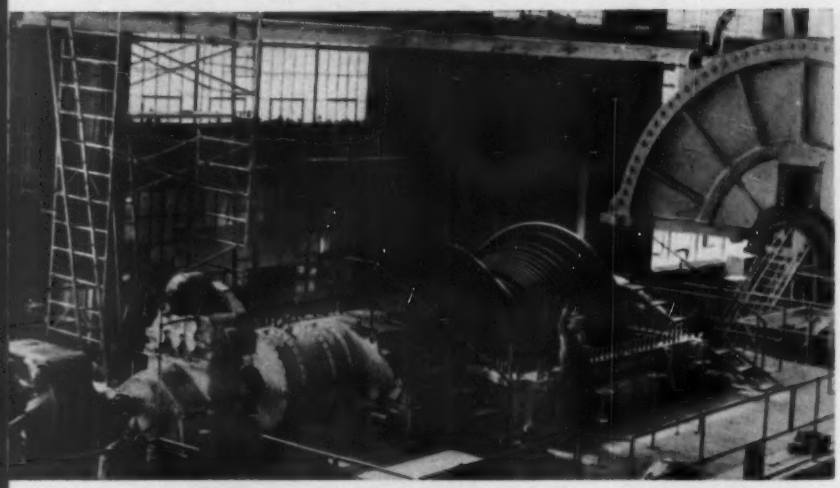
Outer bearing pedestals which support the inner pedestals span almost the entire width of the foundation, Fig. 2. These outer pedestals are a boxlike fabricated construction with internal stiffeners. Electric motors drive pinions engaging racks bolted to the foundation, moving these pedestals as needed. This adjusts the span for different-length spindles. These pedestals also support two steel beams carrying the shell sections of the 3600-rpm box.

Box shell encloses the entire spindle except for the bearing projections at each end. The shell consists of separate pieces to give the needed box length.

The 1800-rpm shell has two end covers of cast steel, flanged and bolted together on a horizontal diameter. Circumferential and radial ribs give stiffness and strength. Steam glands bolted to the cover seal the annular space between spindle-bearing projections and the end covers. End covers bolt around their circumference to cylindrical shell sections flanged and bolted together along the horizontal center line. Four cylindrical shell sections are 10, 3, 2 and 1 ft long, giving 1-ft increments of box length from 10 to 16 ft. This accommodates any existing 1800-rpm spindle—additional sections can be added in the future as they're needed.

The 184-in. inside diameter can take 1800-rpm spindles with blades 45-in. long in the last rows. Diameter increases to about 200 in. with two special cylindrical sections having circumferential bolting flanges on the box interior. Pipe-flange connections in the lower half of each cylindrical section admit cooling or heating steam or evacuate the shell. Insulation on section exteriors protects personnel working near the box.

The 3600-rpm box has same general construction as the 1800-rpm box with a few exceptions. It has some sections that may be heated electrically, firebrick-lined with insulation between brick and the steel shell. The heated sections accommodate blade-



3 Cover being removed from the 1800-rpm heater box. Spindle continues turning at 30 rpm to cool to ambient after rotation test has been completed in the heater box

tip diameters of 80 in. Sections that aren't heated electrically have an inner diameter of 104 in. and accommodate the 25-in. blades of low-pressure spindles.

Supporting beams for both 3600- and 1800-rpm heater-box shell sections have hydraulic cylinders attached to chains. Hydraulic cylinder moves box sections along the beam when linked through the chain. This speeds up the job of rearranging the heater box for spindles of different size.

When using the 3600-rpm heater box, a high-temperature zone must often be established next to a relatively cool zone. To do this a baffle or diaphragm is bolted between adjacent box sections. The baffle extends down to the spindle body and seals one zone from the adjacent one.

Drive turbines, rated 6000 hp at 4320 rpm, drive the spindle in the forward rotation. A 1500-hp reverse turbine, hooked up in tandem, brakes the spindle to a quick stop when vibration becomes severe. The drive turbines run condensing. A paper-mill type governor controls the forward-drive unit over almost the whole speed range.

A turning gear mounts between drive turbines and spindle for slow-speed operation. A 15-hp motor drives the spindle at either 2 or 30 rpm when turning gear is engaged. A tilting-pad thrust bearing inside turning-gear housing carries any thrust load produced by the test spindle. Drive turbine has its own thrust bearing, and connects to the turning-gear shaft through a flexible coupling.

Electric heaters. To raise 3600-rpm test spindles to normal running temperature, especially high-pressure spindles with short blades, strip type resistance elements add electrical heating to the windage heating. Five transformers supply the resistance elements with a 50-v energy source. Automatic temperature controller - recorders actuate relays to turn power to heaters on and off. Thermocouples measure box's atmospheric temperature and furnish signals to the recorder. Box may be held at any fixed temperature up to 1300 F. Any one of several controllers can supervise a separate zone of the box when partitioned.

Cooling steam. Heater-box atmosphere absorbs the output of the drive turbines as internal energy through windage from the spindle. To reduce the power demand, box is evacuated to about 3-in. Hg abs. Despite this, the test spindle sometimes heats more than needed. Then relatively cool steam is admitted to the heater box for control under regulated temperature.

The shop header supplies 600-psig 600-F steam that can be admitted to the heater box in three ways: (1) for low-pressure spindles (2) for intermediate-pressure spindles and (3) for high-temperature soaking.

Cooling low - pressure spindles, tested at low temperatures, involves reducing steam pressure, desuperheating, passing it through a moisture separator and admitting it to the heater box with a further pressure reduction. This steam always enters the box with some superheat to keep water droplets from reaching the spindle.

To cool high- or intermediate-pressure spindles tested at medium to high temperatures, shop steam is reduced to about 15 psig by automatic valves and admitted to the heater box with a second pressure reduction to about 3 psia. This gives a very high superheat, making it impossible for water droplets to impinge on the hot spindle.

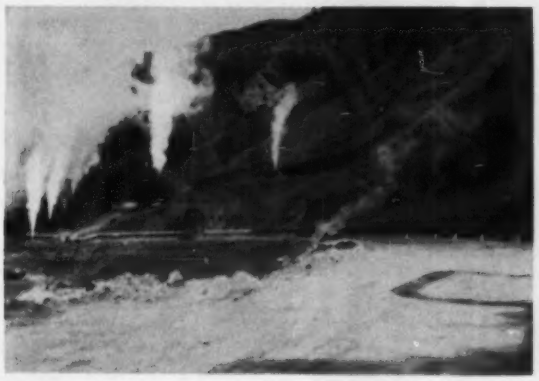
A superheater delivering 600-psig 825-F steam has been added to the cooling system. This will cool spindles heated to 1200 F for metallurgical purposes, and heat l-p 1800-rpm spindles on slow roll.

Extended testing of fully bladed intermediate- to low-pressure spindles generates a tremendous amount of heat in the l-p zone that must be dissipated. Using large amounts of desuperheated steam is uneconomical. A special self-cooling heater-box section was built for this zone, a rectangular duct beneath the cylindrical heater-box shell with openings to the heater box at each side. Spindle's whirling blades pump heater-box atmosphere through the duct. A baffle, closely fitting the blade-tip diameters, helps establish the pumping action.

As atmosphere of the box passes through the duct it evaporates water sprayed into it from 30 nozzles. Thermocouples measuring the temperature in the heater box control the number of spray nozzles at work through solenoid - operated valves.

THE GEYSER'S POWER PLAN, 12.5 mw, stands in rugged site. Turbine building, left, is served by the 3-cell cooling tower, right

BAROMETRIC CONDENSER, right foreground, stands next to turbine building. Big Sulphur Creek flows behind cooling tower

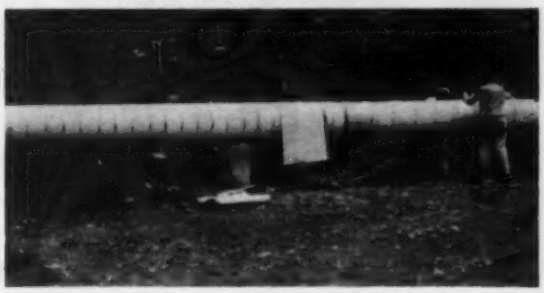


STEAM WELLS will discharge their output into steam-gathering line for delivery to 12.5-mw condensing steam-turbine generator

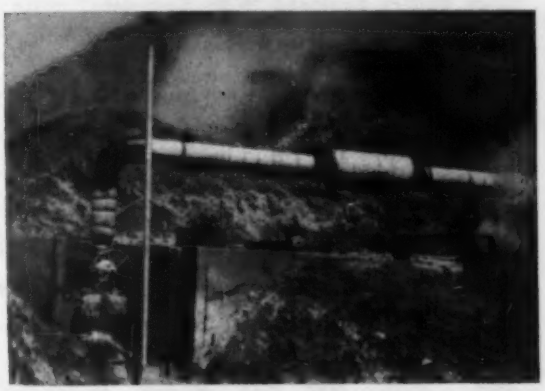
UNHARNESSED WELLS will be allowed to blow free to atmosphere to keep themselves clean. Steam flow seems to increase with time

The Geysers Power Plant gets set to take on load

Pacific Gas and Electric Co's geothermal steam plant went into operation toward the end of June 1960. Here are pictures of the plant described in July 1960 POWER, pp 80-82. Success of first unit will lead to expansion of the installation

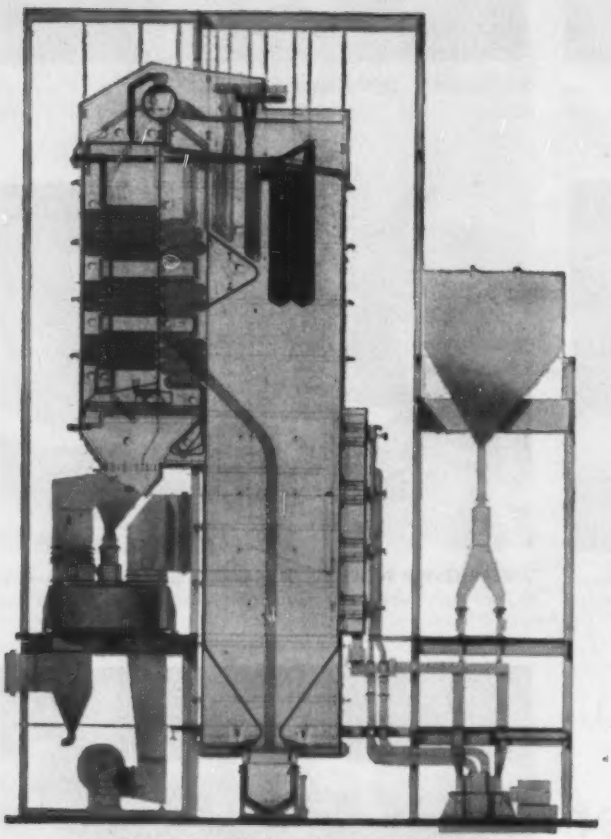


INSULATION PAYS even with "free" steam, to conserve heat and prevent condensation of slightly superheated geothermal vapor

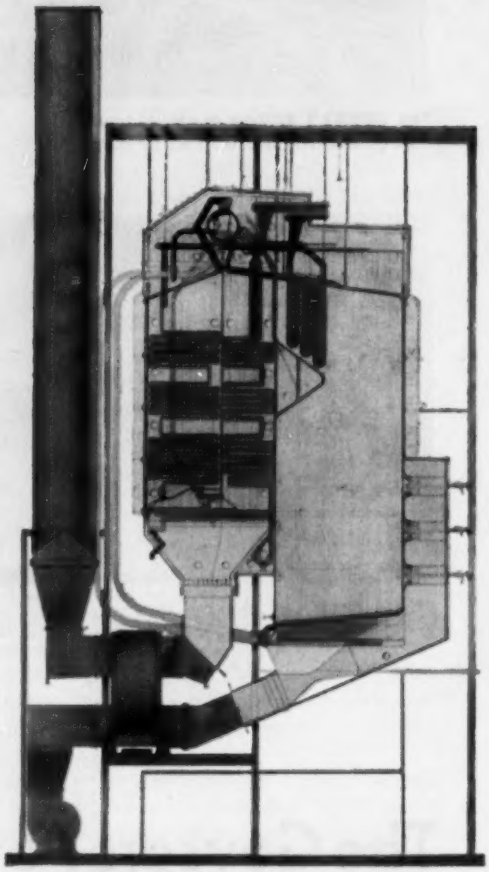


STEAM-WELL HEAD has shutoff valve, discharges its steam through a separator to remove solid particles and moisture drops

Are You Planning To Burn COAL ? OIL or GAS ?



950,000 lbs./hr., 1950 psig, 1000/1000F;
Fired By Riley Pulverizers, Flare Type Burners



1,020,000 lbs./hr., 1925 psig, 1005/1005F;
Fired By Gas, Oil — Pressurized Furnace

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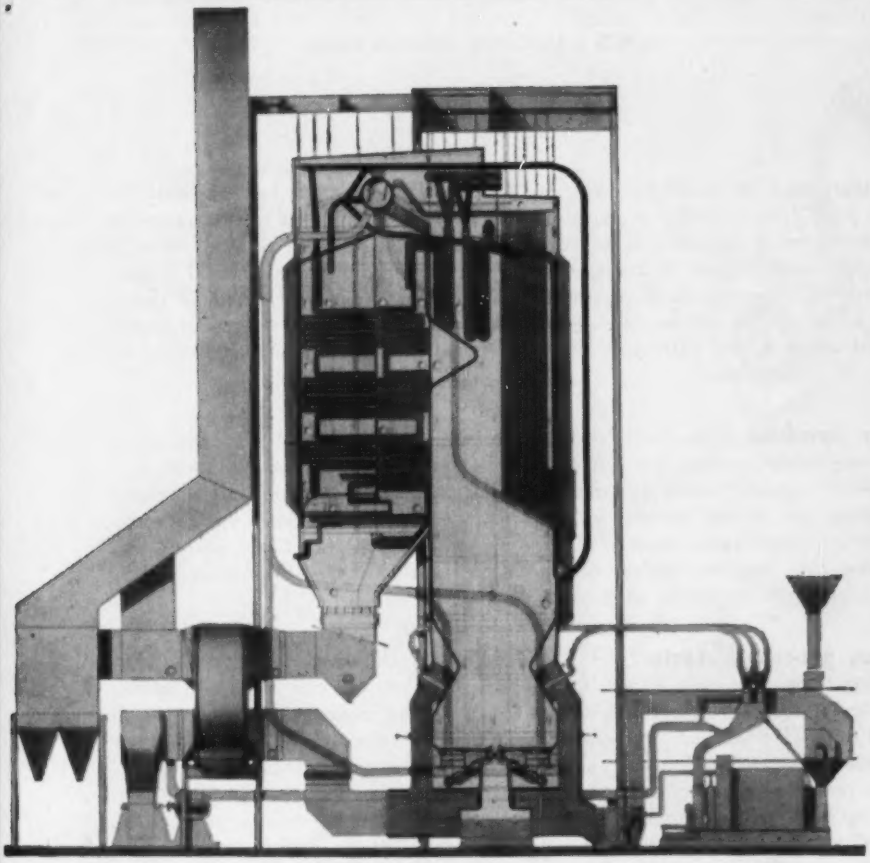
A Survey Of Your Plant by A Qualified Consulting Engineer Can Show You Ways To Make

or ALL THREE ?



1,600,000 lbs./hr., 2125 psig, 1005/1005F; Turbo Furnace with Riley Ball Mills; Pressurized Furnace. Fuels — Gas, Oil, Coal

SOME PUBLIC UTILITIES USING RILEY EQUIPMENT

Louisiana Power & Light Co. (3)
Texas Electric Service Co. (3)
Houston Lighting & Power Co. (13)
Dallas Power & Light Co. (3)
Kansas Gas & Electric Co.
Public Service Co. of Indiana, Inc. (12)
New Orleans Public Service, Inc. (3)
The Holyoke Water Power Co.
Columbus & Southern Ohio Elec. Co.
Central Illinois Light Co. (8)
Hartford Electric Light Co.
Central Power & Light Co.
Monongahela Power Company
Arkansas Power & Light Co.
Southwestern Gas & Electric Co.
Utah Power & Light Co. (3)
Florida Power Corporation (2)
Delaware Power & Light Co.
Minnesota Power & Light Co. (2)
Pacific Gas & Electric Co.
Iowa Public Service Co.
Commonwealth Edison Co.
Manila Electric Co.
Southern Nevada Power Co.
Interstate Power Co. (7)
Northern States Power Co.
Central Louisiana Elec. Co. (2)
Union Electric Co. of Ill. (2)
Northern Virginia Power Co.
Union Electric Co. of Mo. (7)
Pennsylvania Electric Co.
Iowa Electric Light & Power Co. (3)
Iowa-Illinois Gas & Electric Co. (7)
Montana-Dakota Utilities Co.
Mississippi Power Company
Philadelphia Electric Co. (4)
Central Ohio Light & Power Co. (8)
Gulf Power Co. (4)
Otter Tail Power Co. (5)
Public Service Elec. & Gas (N.J.) (7)
So. Carolina Elec. & Gas Co. (3)
Taiwan Power Company (2)

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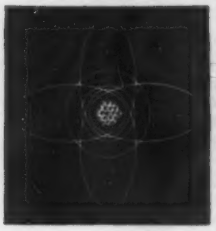

Nuclear notes

By B G A SKROTZKI, Associate Editor

PM-2A reactor, built by ALCO Products, Inc for the U.S. Army, was loaded aboard the MSTS ship *Marine Fiddler* at Buffalo, N. Y. for delivery to Camp Century in Greenland, during the last week of June. The prefabricated power plant, made in 27 packages, can be shipped by air if necessary. It can generate 1.5 mwe and a million-Btu-per-hr space heat from its pressurized-water reactor. Annual fuel supply of 15,500 drums of diesel fuel will be displaced by an equivalent 11-drum volume of highly enriched uranium fuel. Plant will serve camp making polar-research studies expected to start in August 1960.

U.K. nuclear slowdown from about 6000-mwe projected capacity at end of 1966 to about 4500 mwe reflects savings that can be made by expanding conventional fossil-fuel-fired plants instead. British government estimates it will be burning an additional five million tons of coal annually by 1967. By increasing conventional plant installation they expect to realize about $252 million net saving. Conventional power costs are about 25% less than nuclear costs. U.K. National Coal Board is embarrassed by rising coal stocks on hand. (*McGraw-Hill World News*)

TVA will run gas-cooled reactor at Oak Ridge Gaseous Diffusion Plant for the AEC, according to an agreement signed by both groups. Plant will cost about $30 million and generate about 25 mwe for the diffusion plant. The experimental prototype will be used to test fuel elements, gas coolants and reactor materials. TVA will do about $2-million worth of work during installation of which it will contribute about $400,000, the rest to be reimbursed by the AEC. During routine operation TVA will contribute up to $200,000 annually plus a reduction in charges for standby power. The AEC will spend about $3 million annually for operation plus cost of fuel replacement.

PM-3A reactor for McMurdo Sound in Antarctica is being planned by AEC. It hopes to contract for this unit on a fixed-price basis by this month. The 1500-kwe reactor may be either pressurized-water or boiling-water and must be preassembled in packages like the PM-2A, above. The reactor should be tested and ready for shipment by November 1961 and running by early 1962.

Civilian nuclear reactors total 55 as of March 31, 1960 and will cost about $928.6 million; about $421.2 million of this has already been spent. During the 12-month period ending March 31, 1960 both the AEC and private companies have spent a total of $202.3 million.

Forced-circulation boiling-water reactor will be built by General Electric Company for the AEC under a proposal submitted to the Congressional Joint Committee on Atomic Energy. The 50-mwe prototype plant will be installed in San Francisquito Canyon, about 40 miles northeast of downtown Los Angeles, Calif. The plant will be operated jointly by the cities of Los Angeles and Pasadena. AEC estimates nuclear portion of plant will cost $12.5 million. The cities estimate their cost for generating and physical plant will be $10 million. Internal steam-separation equipment in the reactor eliminates steam drum to make it a compact unit. Plant specifications include: 174,000-kwt capacity, 1040-psig reactor pressure, 636,850-lb-per-hr reactor steam flow, 307-F feedwater temperature, 54-mwe gross output, 11,000-Btu-per-kwhr station heat rate. Inside diameter of reactor vessel will be 8 ft 10½ in.

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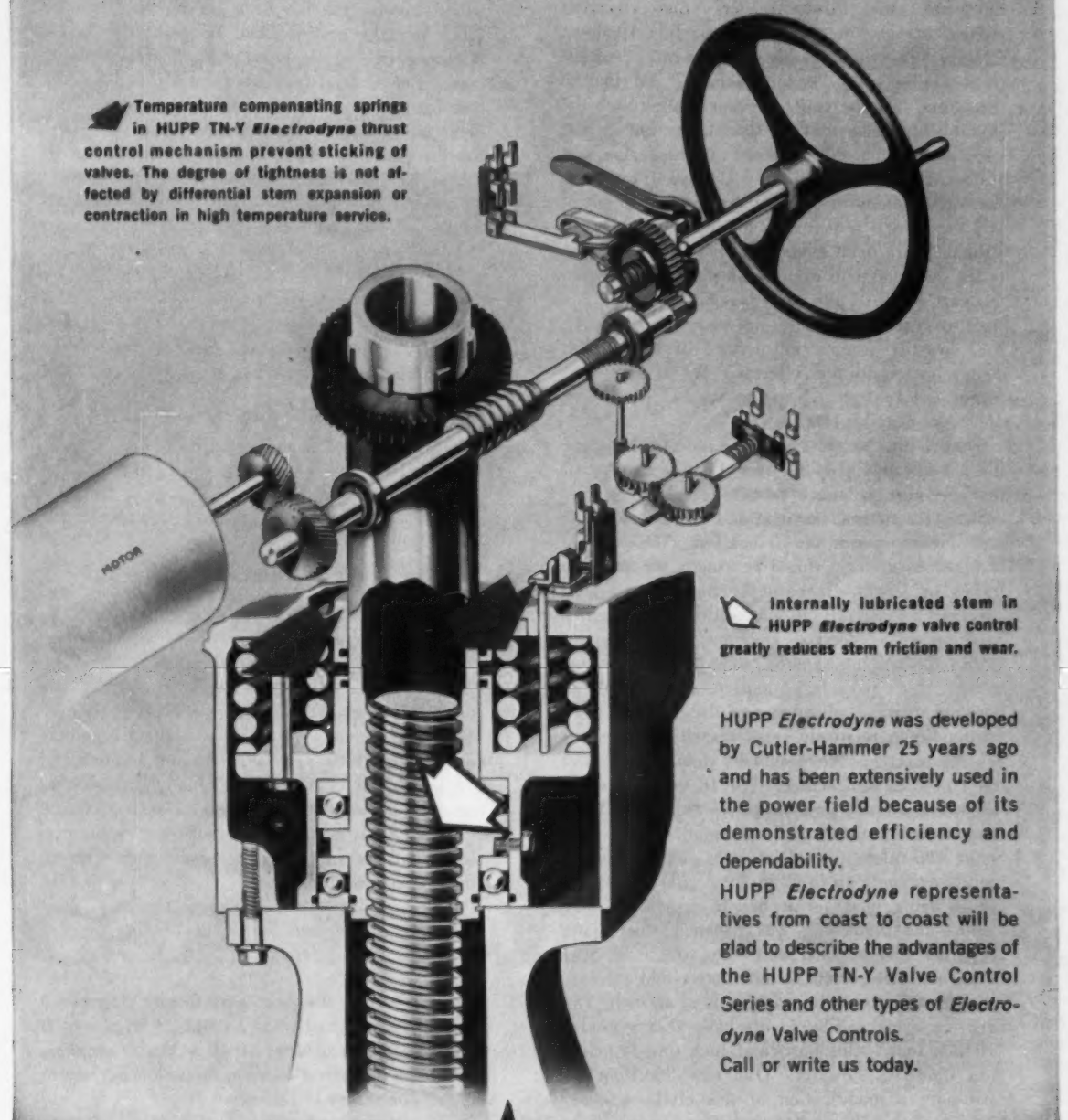
Temperature compensating springs in HUPP TN-Y *Electrodyne* thrust control mechanism prevent sticking of valves. The degree of tightness is not affected by differential stem expansion or contraction in high temperature service.



Internally lubricated stem in HUPP *Electrodyne* valve control greatly reduces stem friction and wear.

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For more facts circle 245 on Reader Service card, p. 119

Reserved for your comment

BOB BELLAS, Associate Editor

Anyone have change for a gunkel?

Mr Baumeister's article intrigued me, as I'm sure it did many other POWER readers (*Energy-systems engineering and the metric system*, July 1960, pp 72-73). Since you probably will get a raft of suggestions dealing with "better methods," I'd like to throw one into the ring. I'm not dealing with the broad field discussed by Mr Baumeister, but suggest we make a simple change in our linear-measurement system. The mathematical unwieldiness of our presently used duodecimal system of inches and feet and the binary system of fractions of an inch are struggled with in all segments of industry. A change to the metric system would take some adjusting on our part, but we'd ultimately benefit—perhaps more than we realize. For those who may not have seen it, I heartily recommend perusal of Dr Edward Telle's views on the subject ("We're losing by inches . . . by feet . . . and by yards," *This Week Magazine*, May 15, 1960).

Though the metric system is a decimal system, it's not the only possible one. I'd like to propose that we (1) use much more widely the existing decimal fractions of an inch and (2) adopt a new unit of measurement, the 10-inch foot. The new unit of foot measurement would be exactly ten standard inches in length. It perhaps could be called a "decifoot" to signify its connection with decimal handling. The decimal fractions involve tenths, hundredths and thousandths rather than eighths, sixteenths, thirty-seconds. Adoption would attain all the mathematical advantages of the metric system, yet require a relatively small transition from our existing practice. We're actually doing this sort of thing now in some cases: (1) In machine shops the inch is already broken up into tenths and thousandths to accurately measure small lengths. (2) Scales and rulers marked in tenths and fiftieths are readily available up to 72-in. long. (3) Increasing use is being made of inches in measuring long lengths and diameters. For instance, steel plates are being sold by inch widths up to 120 in. (4) Some industries, such as automotive and aircraft, are converting to decimal fractions of an inch. (5) Civil engineers and surveyors have always used a "10-inch foot"—this particular inch unit is longer than standard, however. Our new "decifoot" is essentially a modification of this civil-engineers'-surveyors' foot in a more convenient form.

During the transition, departure from the conventional English system might present some minor difficulties. Engineers, designers and draftsmen would have to think in terms of tenths and fiftieths instead of eighths and sixteenths, etc, when designing equipment. But I tried this as an experiment —having had no experience in industries which use the system—and was surprised at the ease and rewarding convenience of using tenths. Estimating and measuring distances longer than about 36 in. would involve the use of a shorter-than-standard foot. Mentally grasping and using the new length might be one of the most difficult transitions to make. But decimal fractions form a sound foundation for this step. Another difficulty might be that drill, tap and bolt sizes presently run by sixty-fourths and not tenths in most of industry. Of course, a 3/8-in. drill is also a 0.375-in. drill.

Transfer of lengths in standard feet and factional inches to "decifeet" frequently would be necessary. But the "decifoot" conversion is relatively simple, multiplying by 12 and moving the decimal point one place. The decimal-fractions conversion is made even more simple by readily available tables. Several examples of decimal fractions and "decifeet" in use would look like this:

5¼ in. = 5.25 in.
10 ft = 12 decifeet (12^{D})
10 ft 5¼ in. = 125.25 in. or $12^{D}5.25$ in.
10 15/16 in. + 2⅜ in.
= 10.94 in. + 2.38 in. = 13.32 in.

R G ELMENDORF, *Pittsburgh, Pa.*

Saki's Fifth Avenue please copy

I think your article, *Industry's battle with fuel ash*, is a most comprehensive one about the corrosion aspects in boiler operation (April, pp 83-88).

As our name implies, we are exporters and importers of metals and machinery and are participating in U.S. export. We are now seeking reputable corrosion inhibitor or residual fuel-oil additive and wonder if you could be kind enough to give us names of some of the producers of such products.

Many of our customers are suffering sulfur corrosion and we are going to supply them with an effective corrosion inhibitor.

T SUEZAWA, *Managing Director*
Metal and Machinery Trading Co, Ltd
Osaka, Japan

EDITOR'S NOTE: *We have sent Reader Suezawa a representative list of some half-dozen suppliers. It is obviously impossible to list all reputable suppliers for him so we extend an open invitation to them to contact him if they so desire.*

Does the end justify the amines?

I noted with interest the item "Preventing fireside corrosion" (*Powerscope*, July, pp 159-160). Melvin Dadd's work is a real contribution.

The trouble with fireside-corrosion problems is that they are generally handled like a social disease;

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BABBITT. Used on soft rods and where corrosion is present, lubrication is limited. Standard Babbitt has tensile strength of 10,000 lbs./sq. in. More expensive type has better wear qualities. Recommended for 5000 p.s.i. pressures, 425°F temperatures.

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*Du Pont Trademark for TFE Fluorocarbon Resin

For more facts circle 246 on Reader Service card, p. 119

much whispering, much misconception, often untreated. We have known about the value of ammonia in retarding corrosion for a long time, have employed it in all formulations of Polyphase Fireside Chemical as standard procedure for the past 12 years, and have run combustible and pH determinations on residual-treated combustion deposits every month as control tests. As a result, we have extensive records of pH values for deposits before and after treatment, in thousands of boilers of all types, firing every conceivable fuel.

Retarding fireside corrosion is only half the battle won. Our interest is also directed toward general reduction of deposits as well as corrosion inhibition, idea being to remove carbonaceous materials to which acid substances adhere. Use of copper chloride in conjunction with ammonium compounds results in a reduction of combustion deposits; particularly carbon, since carbon oxidizes to carbon monoxide in the presence of copper and chlorine is liberated from the copper chloride. Accordingly, much of the carbon is eliminated and what remains adsorbs ammonia.

Few operators realize how effective carbon is as an adsorption agent for gases such as SO_2 and SO_3, and many are somewhat startled by the relatively low pH's that can be encountered in combustion deposits. We have seen them run as low as 0.5. Thus, ammonia is a "natural" antidote since it too is adsorbed by any residual carbon left after copper-chloride treatment. Just how corrosive a combustion deposit can get can be strongly attested to by clothing of personnel who climb into boilers when the units are down for cleaning.

Treatment invariably shows an increase in pH of at least 1.0, many times as much as 4.0. If one realizes that an increase in pH of one integer decreases acidity by one-tenth, it becomes evident that corrosion can be considerably retarded. For example, an increase in pH of from 1.0 to 2.0 means that at 2.0 the deposit is one-tenth as corrosive as it was at 1.0, and presumably boiler metal should last ten times longer. Actually, boiler metal lasts about twice as long: quite an accomplishment!

Handling anhydrous ammonia is hazardous, and certainly impractical for the average boiler operator. Our system of incorporating ammonium compounds in dry powdered formulations enables the operator to employ the ammonia treatment in a manner as safe to handle as ordinary feedwater treatment. Newest development is one incorporating a series of chemical additives for relief of economizer and air-heater corrosion and plugging. It's specifically formulated on bases of fuel used and chemistry of deposits. Aim here is to lower deposits' acidity, lower dew point and reduce volume of deposits. In effect, what Mr Dadd has experienced.

Intriguing thought: using overfire steam or soot blowers as a means of injecting anticorrosion agents into the fireside of a boiler. Many operators already use neutralizing amines and, in some cases, ammonia as a condensate treatment and this might kill two birds with one stone.

T T Peck, *Chief Chemist*
Polyphase Chemical Service, Inc, N. Y.

k for konfusion

We were impressed by your special report, *Piping for energy-systems design* (June 1960, pp 51-66). Power is to be commended for this skillful condensation which should be very helpful to many engineers and designers. We would, however, like to comment on data given on pressure drop through fittings and valves. As the report emphasizes, the starting point in any piping-system design is a determination of the losses in the system and the economic evaluation of these losses. Because this is so important, we would like to add emphasis to the need for using reliable and accurate data for losses in fittings and particularly in valves. Over the years, valve manufacturers have improved valve flow characteristics and unless these are specifically taken into account, the designer can be grossly in error, especially in the design of large high-pressure systems. Several examples will illustrate this point:

Page 63 of the report lists *k* factors for fittings and valves and gives a simple calculation for a 6-in. line. The table gives a *k* equal to 10 for a globe valve in the open position. Considering 6-in. valves and larger, this would be compared to a *k* factor of 0.825 for the Edward Flite-Flow globe valve. For an Edward 90-deg stem globe valve in the open position, it would compare to a value of 3.40. The table lists a *k* factor of 4 for an angle valve in the open position. This would compare to a *k* of 1.55 for a typical Edward cast-steel angle valve. Finally, the Edward Tilting Disk check valve has a *k* equal to 1.0 compared to the value of 2.50 given in the table for a swing-check valve. These examples show how erroneous it can be to rely on published handbook data and indicate the necessity for consulting specific manufacturer's data when calculating the pressure drop through valves.

L H Carr, *Director of Engineering and Research*
Edward Valves, Inc, Subsidiary of
Rockwell Mfg Co, East Chicago, Ind.

Editor's note: *Reader Carr is quite correct;* k *values for valves do vary widely. This is especially true where valves are specifically designed to minimize losses.* k *factors used in our report are based on published data which has proved reliable under average conditions. But where piping is to be kept new-clean throughout its useful life, an appropriate multiplier should be used.*

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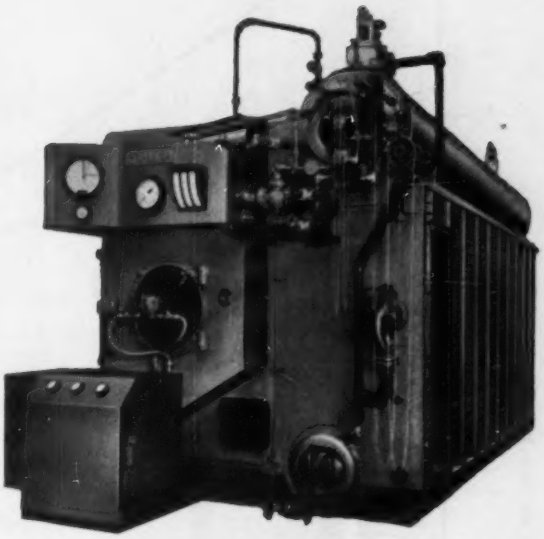
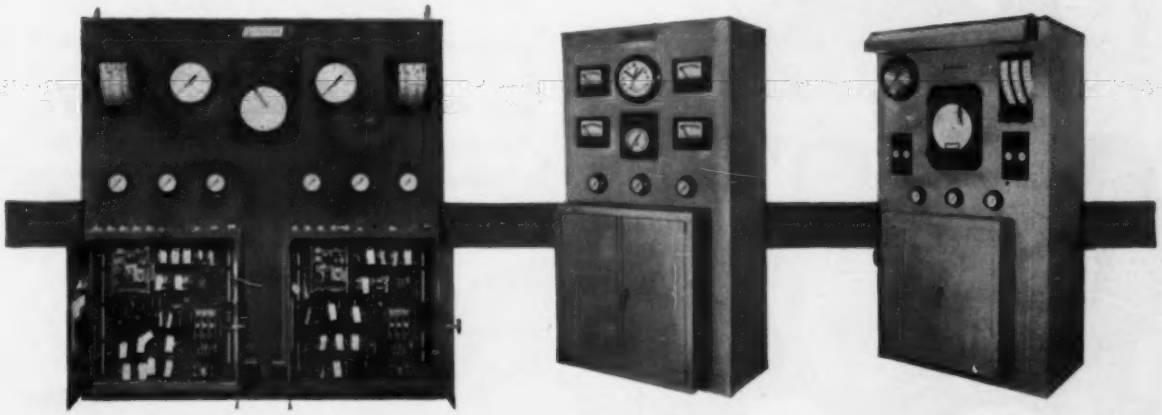


"Type D" Superior Packaged Boiler with integral console for single burners and electric positioning controls.



Duplex panel for two boilers with recording, indicating instruments and individually wired cabinets for combustion safeguard controls.

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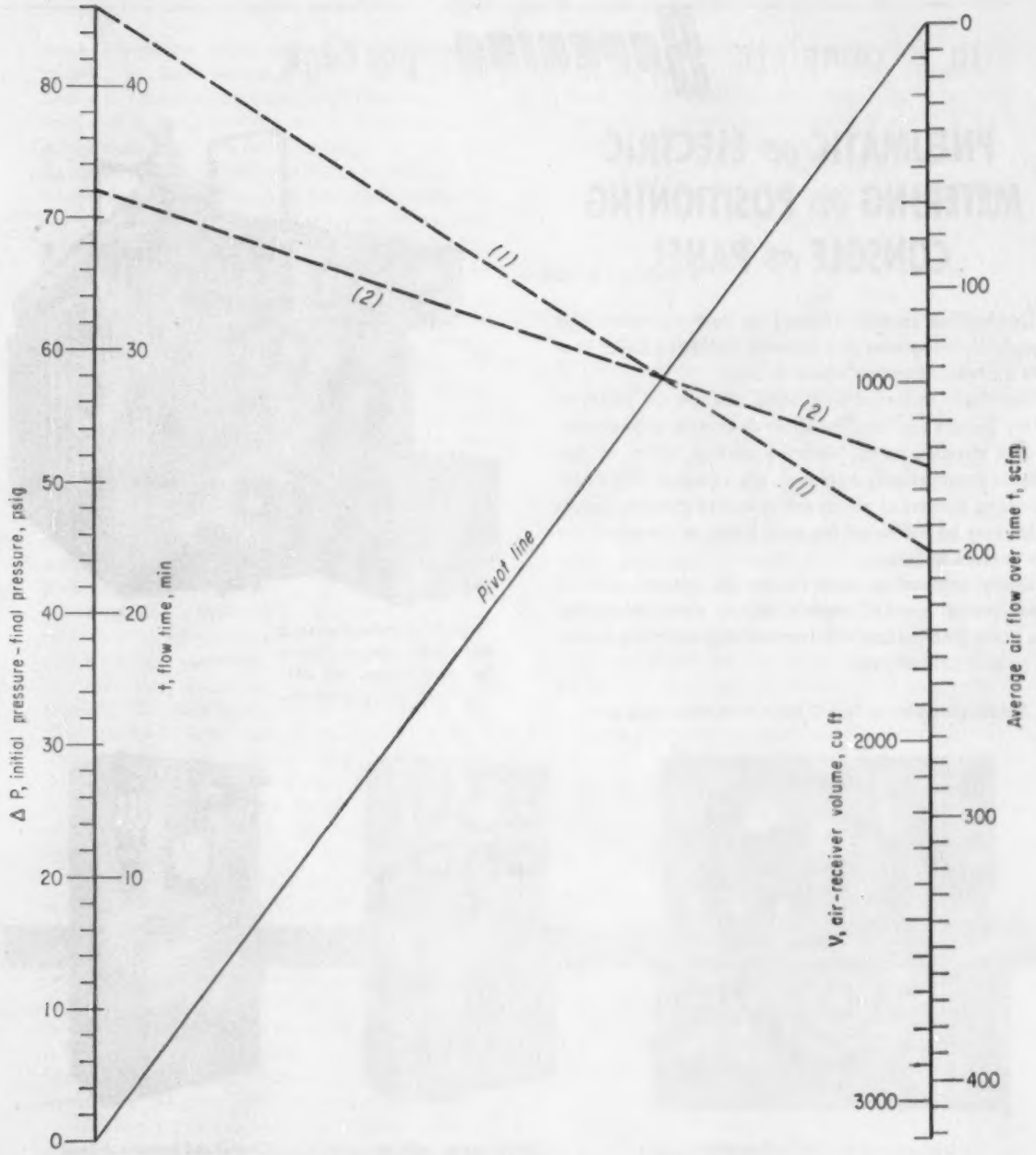
Power's data sheet

No. 336



Air-receiver emergency capacity

Emergency capacity of air receivers becomes an important design consideration when dependability of your air supply is essential.

Chart above offers rapid solution for equation:

$$V = 14.7\,t\,(\text{scfm})/P$$

To use the chart in finding volume, align pressure P with required flow, mark pivot-line intersection, align time t with pivot intersection and read volume V. Actual V is found by dividing scale value of V by the same factor used to bring the value for scfm into range.

Example: What volume air receiver is required to furnish 20-scfm average for 36 min at 44 psig minimum pressure if initial pressure is 130 psig?

Solution: $P = 130 - 44 = 86$. Align 86 with scfm of 200 (actual scfm × 10), mark pivot intersection. Align $t = 36$ with intersection and read $V = 1230$. Actual V is 1230 ÷ 10 or 123 cu ft.

F Caplan, *Oakland, Calif.*

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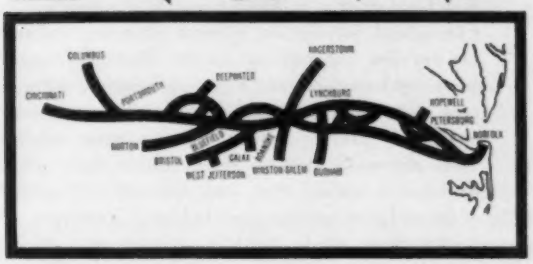

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Technical briefs . . . Latest engineering

Spotlight on lubrication: oil purification, grease and oil tests and fire-resistant fluids

Centrifugal purification of lubricating oils, *C M Ambler, The Sharples Corporation*
Contaminants that accumulate in lubricating systems come from three sources: (1) the equipment —residual core sand from castings or metal particles from gears or bearings (2) the atmosphere—condensation moisture or dust (3) breakdown of the lube itself—carbon in internal-combustion engines. These contaminants may be removed by any one of three purification systems—batch, continuous full flow or continuous bypass. Right one depends on your needs.

In centrifugal purification systems, viscosity index plays an important role. Since index of most common lubricating oils is very steep, heating tends to decrease density of oil faster than that of contaminating water. Separating effect increases in centrifuges that operate on a density-differential basis.

Two basic centrifuges—disk and tubular—are covered in detail. Sizing of purification systems must depend on required contaminant-removal rate with margin to cover emergency conditions such as leaking water jackets. *ASLE 60AM 2A-2*

Centralized lubrication in the steel industry, *E J Gesdorf, Eaton Manufacturing Company*
Centralized lubrication systems in heavy industry are not new, but applications are constantly expanding to include more and more equipment—reducing cost of manual lube. Spray lubrication of heavy gearing is gaining ground. And in many applications automatic systems serve double duty—lubrication *and* sealing dust and dirt out of bearings.

In addition to the steel industry, examples are drawn from sugar mills, packaging and mining operations. In latter case some larger shovel "walking" mechanisms require lubrication every five cycles—equivalent to 30 ft of shovel movement—and a total of 206 bearings need lube every 24 hr. Centralized lube speeds up shovel operation and reduces costs. In one case lube time was reduced from two hr to eight min. *ASLE 60AM 5C-3*

Use of aluminum in lubricating systems—design and specifications, *E E McDole, Kaiser Aluminum & Chemical Company*
Aluminum components—notably tanks and piping —in large circulating lube systems have several advantages for both fabricator and user. All common lubricants are satisfactory for use with aluminum, but the lightweight metal is not recommended where leaded gear oils are used in the presence of water, and should not be used with alkaline waters. Recommended pH range is about 6 to 8.5.

First-cost comparisons between aluminum and steel oil tanks vary widely with physical size. But since aluminum tanks don't need pickling and painting, greatest advantage is reduced maintenance and corrosion resistance. Where combinations of aluminum and steel are used, watch out for differences in thermal coefficients of expansion—that of aluminum is about four times that of steel, so expansion joints are usually a must.

Standard specifications are listed for (1) aluminum pipe—up to 150 psig, 250 F (2) aluminum lube-oil piping—125 psig (3) filler material for welding (4) descaling hydraulic and lube-oil-piping systems and (5) de-mill-scaling small sections of piping. *ASLE 60AM 2B-1*

Degradation of high-temperature lubricants, *J J Murray and E P Scanlan, Chicago Rawhide Manufacturing Co*
In 1957 lubricants had been developed for use and storage in the 350- to 400-F range but elastomeric components available prevented higher temperatures. Under Air Force direction several new elastomers were synthesized for higher temperatures. Chief among these were a fluoroalkyl silicone and a copolymer of perfluoropropylene and vinylidene fluoride. Tests described were to determine corrosive characteristics of fluoroelastomer degradation into hydrogen fluoride.

Variables involved: (1) elastomers (2) lubricants (3) metals and (4) environment. In test series each variable was individually controlled to clearly show effect on corrosion. Both visual and infrared observations were made.

Conclusion: while elastomers are still potential corrosion sources, careful choice of elastomers and environment goes a long way in providing necessary protection. *ASLE 60AM 1A-2*

Evaluation of a fire-resistant fluid in a circulating-oil system, *E J Tullos, Union Carbide Nuclear Company*
Broken oil lines, leaking connections and reduction of oil with process gases and liquids produce fire hazards in lube-oil systems. Fire-resistant lubricants are desirable wherever water cannot be used for fire protection and dry chemicals or CO_2 systems are prohibitively expensive.

Operation of large axial-flow compressors under

developments for busy power men

hazardous conditions prompted use of a phosphate-ester-base fire-resistant fluid (1.15 sp gr) to replace a petroleum-base oil (0.898 sp gr). Operating tests showed completely satisfactory bearing operation.

Fire-resistant lube was introduced into the system *while compressors were running* by installing a centrifuge in a bypass. Lighter petroleum-base oil was gradually separated out, heavier phosphate-ester-base lubricant fed in. Lab tests had shown optimum temperature for separation of lubricants —point of minimum solubility of oil in the fluid. Result: all but 4.5% of petroleum-base oil was removed from system, and liquid removed contained only 12% phosphate ester by volume. And this small amount could probably be removed by distillation if desired. *ASLE 60AM 6A-2*

Disposal and conservation of lubrication oil by re-refining, *A B Two, Motor Oils Refining Co*
Because oils never "wear out," re-refining used lubricating and engine oils is a practical resource-conservation measure. In fact, re-refining usually increases viscosity index of a given oil over original value—it takes out unstable aromatic hydrocarbons. Removal of open-chain hydrocarbons in re-refining process produces oils less prone to oxidize in service than comparable virgin oils.

But distinguish clearly between re-refining and *reclaiming* which merely involves filtration and low-heat treatment. Reclaiming usually does not remove products of oxidation.

Re-refining, by steam- or vacuum-distillation process, is a 7-step method: (1) settling and dehydration removes solid particles and water (2) gums and greases are precipitated by chemical treatment (3) alkaline treatment neutralizes acid compounds (4) soaps formed in neutralization are removed by steam stripping or water wash (5) oil is bleached and certain impurities absorbed by mixing with special clays (6) distillation drives off water, light ends and other volatiles (7) filtering removes clay and all solids still present. In this way re-refining removes *all* constituents except stable hydrocarbons. *ASLE 60AM 2A-1*

Antiwear and extreme-pressure additives for greases, *S F Calhoun, Rock Island Arsenal*
Antiwear and extreme-pressure tests on grease samples with 29 additives used 4-ball, Falex and Timkin testers to evaluate properties. Basic grease was mineral oil rated at 80 ssu at 100 F with preformed lithium stearate. Percent of additives was varied.

Results show that phosphorous increases antiwear properties of grease while lead, sulfur and chlorine increase efficiency under extreme-pressure conditions—sulfur is somewhat better than chlorine. Wear tended to increase as extreme-pressure properties improved, showing need for more work.

Additives can be combined to enhance both properties, but effects vary with grease types. So additives must be fitted carefully to specific grease and intended use. *ASLE 60AM 3B-2*

Electrical distribution

Factors determining primary-substation ownership, *C C Saunders, E I DuPont de Nemours & Company*
Five years ago ownership of substations was about equally split between utilities and the industrial plants they served. Now a definite trend toward industrial ownership seems to evolve. About 80% of substations installed in 1959 were owned by the industrial they served.

Factors determining ownership fall into four areas: (1) utility policy (2) industrial-plant policy (3) size and voltage of substation needed and (4) engineering and operating considerations.

An evaluation form illustrates a typical study. Rate of return on substation investment is basis for decision. But figure in offsetting "tax effect."

Specific installations show shared ownership of substations financially advantageous to both utility and industrial. In these cases, contract should clearly spell out obligations and responsibilities of each party. *AIEE CP 60-800*

Power-company policies in serving industrial plants, *D T Michael, The Cincinnati Gas & Electric Company*
Power-company policies differ widely regarding electric service to industrial plants. So before firming your expansion plans, have a conference with the local utility to determine their requirements and your best approach to adequate service.

Some factors to be covered are: (1) best estimate of maximum electric load to insure adequate line and transformer capacities (2) presence or absence of "flicker"-producing devices which may disturb line voltage (3) required voltage for your equipment (4) point of delivery and right of way and (5) desired location of transformer station. Remember: small industrial plants should avoid owning transformer stations; they normally will not have trained personnel for proper operation and maintenance.

A place to start: AIEE 952 (Red Book), "Power distribution for industrial plants." *AIEE CP 60-799*

Directions for ordering these papers on page 116

continued

These two styles of Allpax Packing cover a wide range of applications and many different uses, consistent with the policy of our company—fewer packings for more services.

Both are compounded of the highest quality materials, and between them they cover against such service conditions as steam, water, air, ammonia, gases, oils, distillates, dowtherm, etc. They are for use on centrifugal and rotary pumps, valve stems, expansion joints and similar equipment.

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Technical briefs

Begins on page 106

Materials

Structural stability of commercial wrought austenitic steels for power-plant piping up to 1450 F, *E A Sticha, Edward Valves, Inc*

Austenitic steels lose impact resistance at high operating temperatures due to structural changes. Extent of impact-strength deterioration was not known quantitatively; now tests made at Edward Valves, Inc over an 8-yr period fill this technological gap.

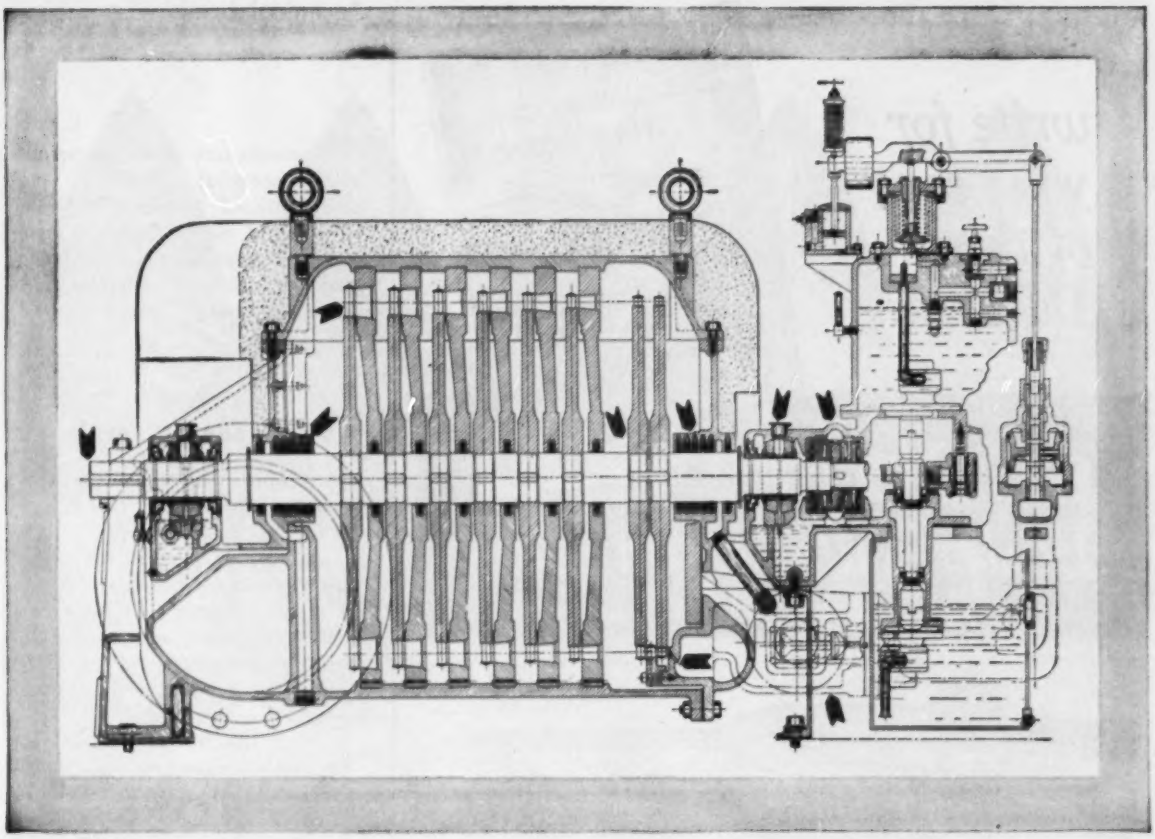
Exposure times of up to 61,000 hr at temperatures up to 1450 F produced consistent data capable of extrapolation to 100,000 hr. Factors bearing on loss of impact strength are formation of *sigma*, a hard iron-chromium compound, and initial chemical composition converted to equivalent chromium, a mathematical summation of elements contributing to shifting phase boundaries.

Some conclusions reached: (1) loss of impact strength is usually greatest at 1450 F (highest temperature tested), but some important exceptions showed greatest loss in 1250- to 1350-F range (2) initial deterioration due to carbide precipitation is minor; greater long-term losses occur because of sigma formation (3) extent of loss of impact strength is function of chemical analysis with lower-chrome-equivalent alloys showing less loss—19.5% chromium equivalent is considered maximum for 1150 F and 18.5% for 1250 F. *APC—1960*

Predicting tube life in high-pressure boiler installations, *J L Menson, W L Harding and E P Petit, Combustion Engineering Inc*

Boiler-tube wastage — reduction in wall thickness—is an extreme variable not only among boilers of the same rating but also among individual tubes within one particular boiler. Nevertheless, careful evaluation of wastage can be used to effectively predict tube life.

Steps in analysis are: (1) evaluation of metal-rupture data (2) evaluation of wastage rate (3) calculation of increasing hoop stress and (4) prediction of time-to-rupture. Details of each step are given and a specific example illustrates the method.



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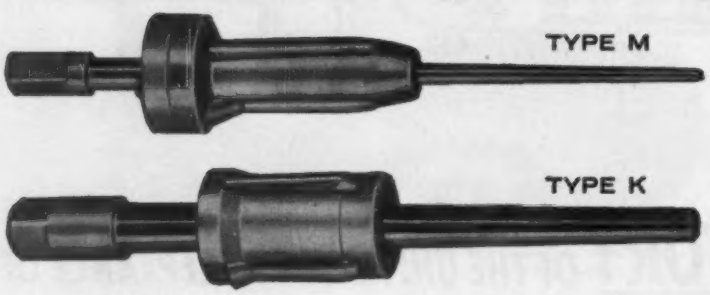

This 16-page bulletin describes general types of Elliott boiler tube expanders for fast, efficient tube rolling jobs. It also gives dimensions, prices and other descriptive data and shows various drum, header and short series mandrels which are used with Elliott boiler tube expanders. Drum mandrels are seen with Type M and Type K above.

Accessories available to adapt Elliott boiler tube expanders to various tube rolling applications include universal joints and extension shafts, sockets, gear drives, etc. A new heavy-duty, right-angle gear drive utilizes roller bearings to minimize friction, cutting down power losses.

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Technical briefs

Begins on page 106

Time-to-rupture prediction permits most economical maintenance program, planned outages and better estimates of outage time and manpower requirements. Information concerning temperature limitations, start-ups and hot restarts is also obtained. *APC—1960*

Other energy services

Some applications of the low-level economizer, *J H Potter, Stevens Institute of Technology*
Use of low-level economizers can produce significant thermal savings in a variety of industrial and utility heat cycles. Corrosion and plugging investigations have shown feasibility, appropriate temperature ranges and physical designs required.

Several cases cited show savings: (1) At a Canadian paper mill, 2904-sq-ft low-level economizer circulates 30,000 lb per hr for air tempering. Heat-recovery savings are $6000 per yr. (2) At Dayton Power and Light Co, air tempering loop circulates some 500,000 lb per hr for a $21,400 annual saving. (3) Feedwater heating is accomplished at Philadelphia Electric's Eddystone Station through use of low-level economizer. Several other designs are discussed including building heating. *APC—1960*

Mechanical-draft fans in the future—critical areas in application, *W E Wendover, American-Standard Industrial Div*
Extrapolation of growth in fan technology and requirements during the last 20 years indicates progress to be expected during next decade. But as is frequently the case with power-plant predictions, accelerated growth rates may shorten the time.

Trend areas include: (1) optimum number of fans per unit (2) methods of capacity control (3) fan design limitations (4) fan noise and (5) equipment and duct layout.

Trend towards fewer but larger fans per unit will continue, limited only by commercial availability of equipment. Fan wheels of 10- to 12-

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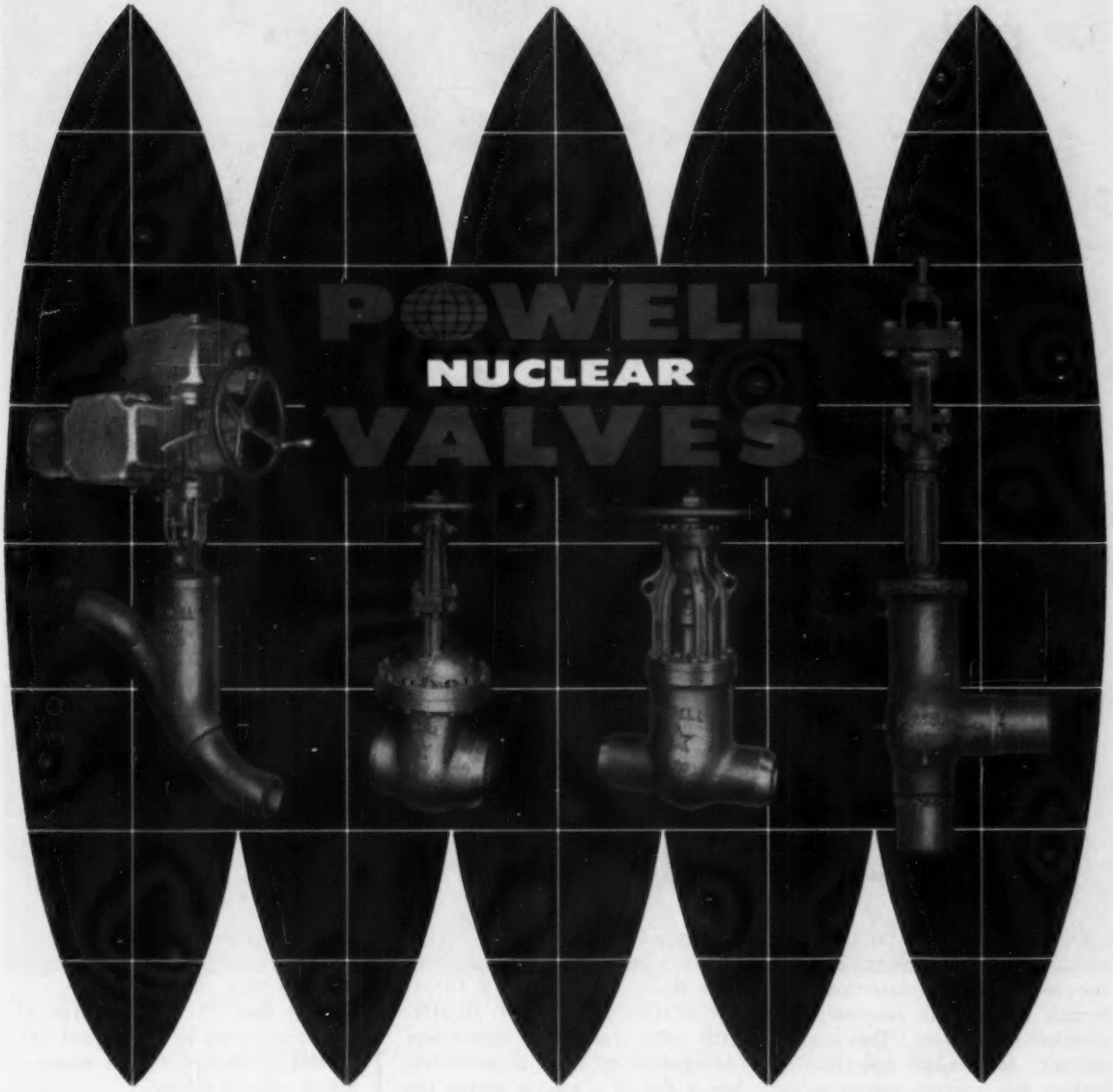

*4-inch steel Bell-O-Seal "Y" valve for 300 pounds pressure.

Fig. 3003 W. E.—Steel bolted bonnet gate valve for 300 pounds W. P. Bolted bonnet valves can be supplied for pressures from 150 through 2500 pounds.

Fig. 19003—Steel pressure seal gate valve for 900 pounds pressure. Also available in 600, 1500, 2500 pounds W.P.

*3-inch steel, Bell-O-Seal Freeze Seal angle valve for 150 pounds pressure.

*These two valves are specifically designed and made to provide absolutely leak-tight control of liquid metals in the reactors of nuclear power plants.

Keeping pace with nuclear advancements — Powell manufactures valves to handle molten metals and other radioactive materials in atomic power plants—vital and hazardous materials which must be contained in and pass through the valves without the slightest leakage or failure.

Painstaking quality control is rigidly enforced in each step of manufacture of these important valves. Test facilities and inspection meet the most exacting specifications. For complete information on Powell nuclear valves, consult your nearest Powell valve distributor or contact Powell directly.

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HEV-E-OIL commercial-industrial burners operate on the principle of low-pressure air atomization and furnish *all the air necessary for complete combustion.* This assures efficient, economical operation — perfect fire control regardless of weather or draft conditions. And HEV-E-OIL burners offer you *double savings!* They are especially engineered to make use of inexpensive heavy oils — number 4 and 5. Number 6 or Bunker C in larger models. Available from 5 to 150 gph.

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Technical briefs

Begins on page 106

ft diameter weighing up to 35 tons will not be uncommon as compared to 8-ft-diameter fans available today. Fan-noise studies will continue and as more is learned, designs will benefit. Increased rotor WK^2 will aggravate motor-startup problems where variable-speed drives aren't used. *APC—1960*

Diesel-electric generation

Internal-combustion engines in steam-power stations, *G C Boyer, Universal Engineering Co, McPherson, Kansas*

Since 1949 six diesel-engine generators operating with steam-electric stations have been installed in the central plains states. They satisfy several combinations of three basic needs: (1) standby source of power for steam-station auxiliaries (2) firm capacity until additional steam capacity is installed and (3) peak-load generation.

Many specific instances are cited to illustrate diesel-electric operation to meet the three needs. Operating experience has definitely shown feasibility of parallel operation with steam units.

Diesel-electric-generator sizing depends on: (1) hp in station auxiliaries needed in emergencies (2) lighting load (3) hp and type of largest motor to be started and (4) method of starting largest motor—full or reduced voltage.

Where diesel-electric generators are small and for emergency use only, oil burning is probably best. But where peak loads are to be carried, economies of dual-fuel type often justify additional investment. *ASME 60-OGP-1*

Some experimental results from a 2-cycle diesel-engine-exhaust waste-heat exchanger, *J C Georgian, Washington University*

Exhaust waste-heat-exchanger tests for diesel engines reveal heat-transfer characteristics and noise levels at various gas velocities. A^2 1200-rpm

The "slave-hands" of an AI technician handle radioactive materials through a hot cell window 3½ feet thick. *Woodcut by Edward Kysar.*

Let A.I.'s experience guide your Nuclear Power Program

The largest privately-owned facility in the world for remote handling of radioactive materials is located at Atomics International's 290-acre field laboratory near Los Angeles. Here the men who pioneered the creative peacetime uses of atomic energy are applying their 14 years of experience to developing advanced nuclear reactors and associated equipment.

Much of AI's work has been on projects for the U.S. Atomic Energy Commission. This includes the Organic Moderated Reactor Experiment at the National Reactor Testing Station in Idaho and the Sodium Reactor Experiment in California. AI has also built and is operating SNAP II, a 220-pound prototype reactor designed to produce 3 KW of electricity for space vehicles.

With some of the most sophisticated facilities in the world at their disposal, the men at AI are now conducting studies for large power station reactors in the United States and Europe. Two reactors are now actually under construction under AEC programs—an Organic Moderated Reactor in Piqua, Ohio, and a Sodium Graphite Reactor in Hallam, Nebraska. Smaller research reactors have been built by Atomics International for Denmark, Germany, Italy, Japan, Puerto Rico and several sites in the U.S.A.

For details contact: ATOMICS INTERNATIONAL, Canoga Park, California, U.S.A. Cable address: ATOMICS.

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Technical briefs

Begins on page 106

2-cycle diesel engine exhausted to a single-pass heat exchanger with baffled 2-pass arrangement on the water side. Gas velocities were varied by plugging tubes. Sound-level readings were taken both with and without a silencer in series with the exhaust waste-heat exchanger.

Conclusions: Highest possible gas velocity should be maintained since coefficient of heat transfer is then highest—14.13 Btu per hr per sq ft per deg F at 100 fps vs 4.62 at 25 fps. Sound level decreases with reduction in number of tubes, but pressure drop across heat exchanger increases. In some cases use of exhaust waste-heat exchanger may eliminate need for silencer. In others the two elements can be conveniently combined. *ASME 60-OGP-13*

Power-cost studies for systems with diesel-generating stations, *W H Reed, Rural Electrification Administration*

Detailed power-cost studies are best test of possible sources or combinations of sources. Illustrative example is based on accepted Federal Power Commission uniform system of accounts to assure best possible comparison—makeup of each account is known.

Plant studied has initial capacity of 28 mw, made up of four 7000-kw generators each driven by two back-to-back 3500-kw engines, to supplement purchased power. It provides for expansion to 42 mw in five years. Detailed study produces total power costs—purchased and generated power and standby costs. These would be compared to costs of other schemes to establish best overall plan.

In arriving at fuel costs take care to allow difference between higher heating value used by gas companies and lower-heating value basis of diesel-engine heat rate. In setting depreciation, general REA policy is used—3% for 720 rpm or less, 6% for 900 and 1200 rpm and 10% for 1800 rpm. *ASME 60-OGP-12*

continued

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These high-efficiency units may be designed for non-condensing, condensing, mixed pressure or bleeder operation. Can be equipped with constant or variable-speed governors, special governors, remote controls. Sizes up to 5000 HP — Speeds up to 10,000 RPM. Ask for Bulletin S-146.

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These are also the reasons why you should consider a Terry turbine for your next mechanical drive. In the meantime, send for bulletins describing any of the types of machines illustrated.

THE TERRY STEAM TURBINE COMPANY
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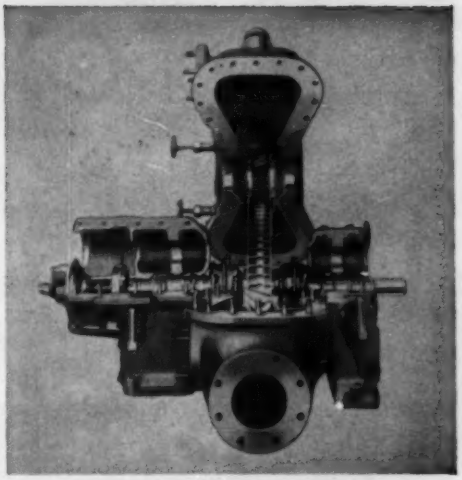

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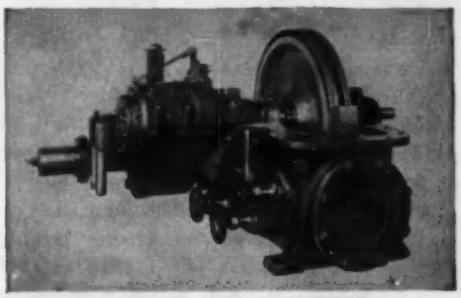
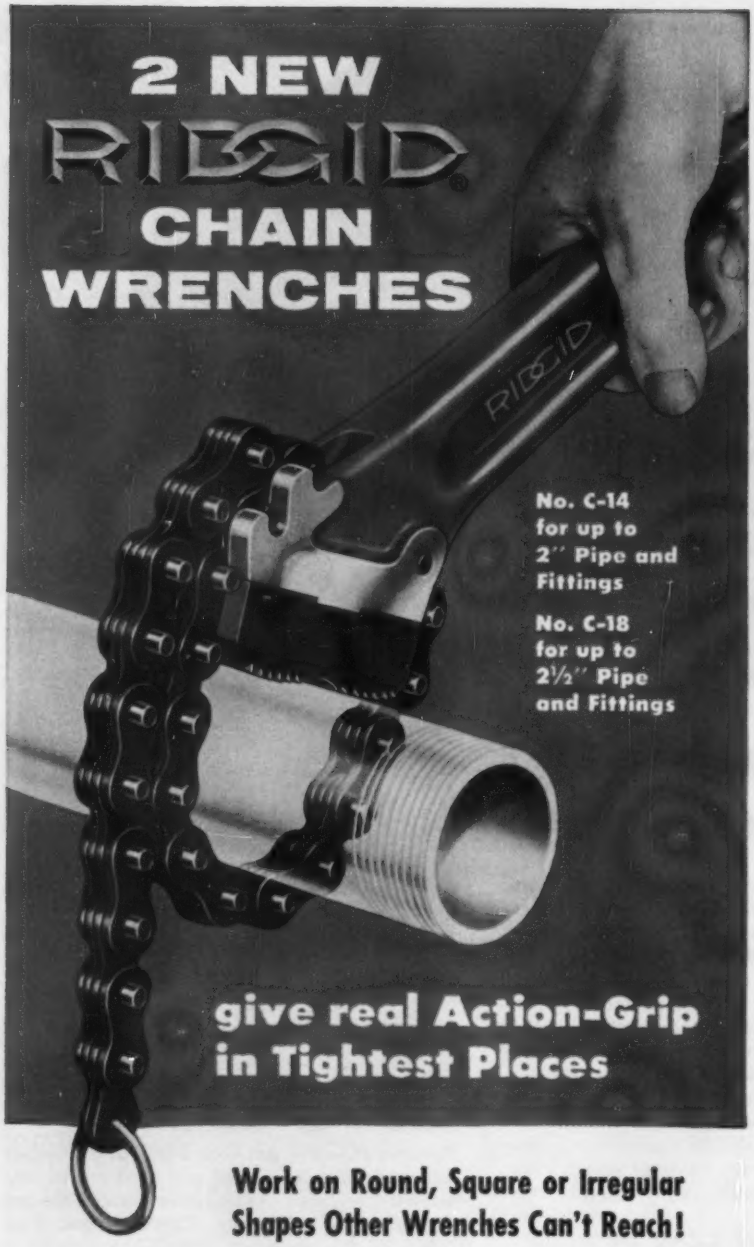


AXIAL-FLOW IMPULSE TURBINES

Built with one, two or three rows of high-grade stainless steel blading, these turbines combine efficiency with durability. Available in designs for moderate and high steam pressure. Bulletin S-143.

17-1289



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Technical briefs

Begins on page 106

Cost comparison — diesel and steam, *S K Fosholt, Stanley Engineering Co, Muscatine, Iowa*

Several cost comparisons between diesel and steam plants show factors to be considered. Basis of comparison is 33,000-kw plant maximum with one steam unit or multiple diesel units—5000 kw maximum.

Factors include (1) fuel cost (2) investment cost (3) reserve requirements (4) fixed charges (5) payroll costs and (6) maintenance. While steam-plant unit investment decreases throughout range studied, unit investment for diesels levels off at about 2000 kw. Depreciation rate for diesel plant should be set about ½ to 1% above comparable steam plant. Below 20,000 kw, payroll costs slightly favor diesel plant, but maintenance costs are taken as equal in plant-size range studied. Other factors favoring diesel plant include (1) cooling-water requirements (2) simplicity (3) space and (4) starting time.

In examples given, high load factor with no reserve favors steam plant in all capacities—6000 to 30,000 kw. But with one unit in reserve and low load factor, diesel plant shows lower total cost. *ASME 60-OGP-2*

To obtain complete text

Material for these abstracts comes from the following sources. Order complete paper from source, not POWER.

American Society of Lubrication Engineers. Contact ASLE, 5 North Wabash Avenue, Chicago 2, Ill. Members, 50c; nonmembers, 75c.

American Institute of Electrical Engineers. Contact AIEE, 33 W 39th St, New York 18, N. Y. Members, 50c; nonmembers, $1.00.

American Power Conference. Papers will be published in book form. Contact Illinois Institute of Technology, Technology Center, Chicago 16, Ill. Price, $8.00.

American Society of Mechanical Engineers. Contact ASME, 29 W 39th St, New York 18, N. Y. Members, 50c; nonmembers, $1.00.

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S-A "CARQUAKE" CAR SHAKER
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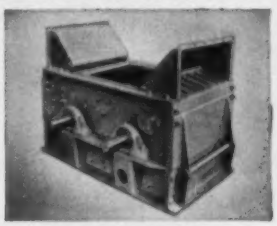

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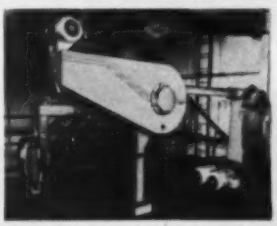

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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75
76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

NEW LITERATURE listed in this issue, starting on p 119

101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125
126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150
151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175
176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200

ADVERTISED PRODUCTS appearing throughout the issue

201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225
226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250
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376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400
401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425
426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450

SEARCHLIGHT SECTION for used and rebuilt equipment, starting on p 230

500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524
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New free literature

General equipment and key materials for systems engineering

• **Instruments**

101 **Thermocouples,** small diameter, mineral-insulated type, are topic of brochure G 100-4. Specs and ordering info are included. Minneapolis-Honeywell Regulator Co

102 **Test equipment** and panel instruments for industrial applications are described in well-illustrated booklet 28. Precision Apparatus Company, Inc

103 **Metal-sheathed** ceramic-insulated thermocouples are explained with typical applications in folder P1281A. The Bristol Co

104 **Thermocouples and assemblies,** stainless - steel - forged thermowells are covered in bulletins, TT - 307, TT - 306. Temperature ranges, performance specs are given. Trinity Equipment Corp

105 **Lab and testing instruments** are covered in 14-p folder E 6. Potentiometers, galvanometers, ac and dc null detectors are some of the instruments described. Leeds & Northrup Co

106 **Engineer's manual** on steam and water service guides selection of automatic heating and cooling controls. Systems and examples for solving control problems are included. The Powers Regulator Company

• **Insulation and coatings**

107 **Thermal - insulating - materials** brochure emphasizes economic-thickness approach to specification. Includes section on ASTM and government specs. National Insulation Manufacturers Assn

108 **Insulating channel** and angle stock for structural applications is described in folder. This describes how high-strength fiberglass-reinforced polyester shapes can replace stand-off insulators, wood and insulating metallic members. The Glastic Corp

109 **One-piece pipe insulation,** thermal and physical characteristics for below zero to 350 F are covered in 4-p bulletin J-660. Baldwin-Ehret-Hill, Inc

• **Maintenance**

110 **Steel-spring machinery mounts,** data on stopping vibration, shock and noise transmission are covered in 6-p bulletin K3C. The Korfund Co

111 **Solving clamp problems** is topic of catalog describing tube, hose clamps, stainless - steel worm-gear clamps. Clamps can be used for duct and plastic pipe. Wittek Mfg Company

112 **Instruction data booklet** tells how you can do industrial maintenance jobs without skilled mechanics. Repairing expansion joints, producing corrosion-resistant surfaces are two topics. Stonhard Co, Inc

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• **Lubrication**

113 **Equipment** continuously feeds lubricating oil to a pile hammer —without passing it through air or steam hose. Method is explained in brochure available from McKiernan-Terry Corp

114 **Lubricating equipment** for handling many oiling jobs is covered in catalog X-135. Oil-Rite Corp

• **Metals and materials**

115 **High-alloy castings** are covered in technical-publications booklet. Lists technical papers, articles, reprints, data sheets resulting from information program. Alloy Casting Institute

116 **Primary- and mill-products** booklet reviews shapes, sizes and alloys in primary-aluminum pig, ingot and billet and in wrought-aluminum mill products. Harvey Aluminum

117 **Ceramic permanent magnets,** uses are covered in 8-p bulletin 355. Indiana Steel Products

• **Welding**

118 **New flux eliminates** painting metal to be welded with powdered flux, dipping welding rod into powdered flux. Details are in form 659. Rexarc, Inc

119 **Electron-beam welding** welds by direct bombardment of metal with accelerated electrons in a vacuum chamber—especially useful for newer metals and alloys. Bulletin ADC 937 tells story. Air Reduction Sales Co

120 **Factors to consider** in selecting arc-welding electrodes are covered in bulletin giving info on ASTM and AWS classifications of steel-arc-welding electrodes. Hobart Brothers Company

121 **Guide to better welds** is vest-pocket-sized booklet containing 80 pp of arc-welding info. Hobart Brothers Company

• **Valves, piping, fittings and specialties**

122 **Globe valves** are covered in spec sheets 70-18, 73-26. Valves are rated at 3000 and 6000 lb. Black, Sivals & Bryson, Inc

123 **Butterfly valves** for control of large volumes of liquids or gases are topic of 4-p folder. Worthington Corp, Mason-Neilan Div

124 **Control valves** with venturi-ball design are described in 16-p catalog GV-101. Valves will handle pressures to 50,000 psi, temperatures from −425 to +1200 F. General Kinetics Corp

125 **Double-cushioned check valves** prevent hammer and shock due to back surge, handle water, gas, oil and other fluids. Details are in 4-p bulletin WS-1A. Golden Anderson Valve Specialty Co

126 **Pure-beryllium tubing** is described in data sheet 26. Superior Tube Company

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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
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51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75
76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

NEW LITERATURE listed in this issue, starting on p 119

101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125
126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150
151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175
176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200

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201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225
226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250
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401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425
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127 **Seamless light-wall tube** is processed in strip form and rolled up for shipment. Details are in 8-p form available from Wolverine Tube Div of Calumet & Hecla, Inc

128 **Seamless welding fittings** are covered in 12-p bulletin 60-C. Midwest Piping Co, Inc

129 **Piston packings** are for single-lip piston seals in hydraulic or pneumatic applications wherever there is reciprocating motion. Bulletin K-260 gives details. Greene, Tweed & Co

130 **Seals,** their engineering and applications are described in 8-p bulletin AD-150. Garlock, Inc

131 **Pipeline strainer** for condensate, steam, water, oil, air or gas is topic of 4-p bulletin 1210. Sarco Company

132 **Packing - recommendation chart** simplifies selection. Raybestos-Manhattan, Inc

Air-conditioning systems

• **Air-conditioning units**

133 **Air - conditioning equipment** is featured in 24-p catalog of firm's complete line. Catalog B-5529 also includes air-handling equipment, fluid drives, heat exchangers. American - Standard, Industrial Div

134 **Air - conditioning** and refrigeration catalog R460 lists complete line of flared tube fittings. Madden Brass Products Co

135 **Vibration and noise control** specifications for air-conditioning, related equipment are in 6-p bulletin FBD. The Korfund Co, Inc

136 **Centrifugal-fan cooling towers** in 5- to 30-ton sizes for vertical or horizontal air flow are topic of 4-p specification. Halstead & Mitchell Co

137 **Packaged air conditioners,** firm's complete line, are covered in 12-p bulletin 6022. Dunham-Bush, Inc

• **Ventilation**

138 **Ventilating and heating** units are presented in 24-p catalog available from McQuay, Inc

139 **Centrifugal airfoil - bladed fans** are described in 60-p bulletin A-1103. Applications, modifications, specs are given. American-Standard Industrial Div

140 **Ventilating equipment,** corrosion resistant type with options in materials and coatings, is explained in 4-p bulletin 1117. Hartzell Propeller Fan Co

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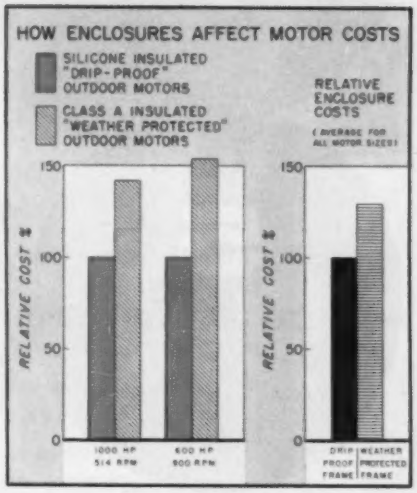
There's No Price Premium . . . Just Savings . . .When You Specify Silicone Insulation

For Outdoor Locations: You can save 30% and more on initial cost of form-wound motors by specifying silicone insulation systems made with Silastic, the Dow Corning silicone rubber. Here's why: 1) Silicone insulated motors are now available at no price premium; 2) The insulation system itself is self-protecting, shrugs off weather, humidity, corrosion, dust, even flooding. There's no need for elaborate enclosures that push motor prices up and up. The chart (right) shows how much you save by specifying silicone insulated open motors.

For Indoor Locations: Where ambient temperatures are high, where corrosive fumes or industrial contaminants are present; where relative humidity is pushing 100%; where motors are hosed down — in all these applications and others, too, expensive motor enclosures, and often expensive ducting as well, can be eliminated by specifying silicone insulation.

For Any Location: Silicone insulation systems increase motor service factor by as much as 15 to 30% because of their greater thermal stability. This increased service factor means there's no need to overmotor for occasional overloads . . . and suffer the power factor penalty of part loaded induction motors.



This chart shows one of the ways you save by specifying motors insulated with Silastic.

New brochure on Silicone Insulation. Write for your free copy. Address Dept. 7008.

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.

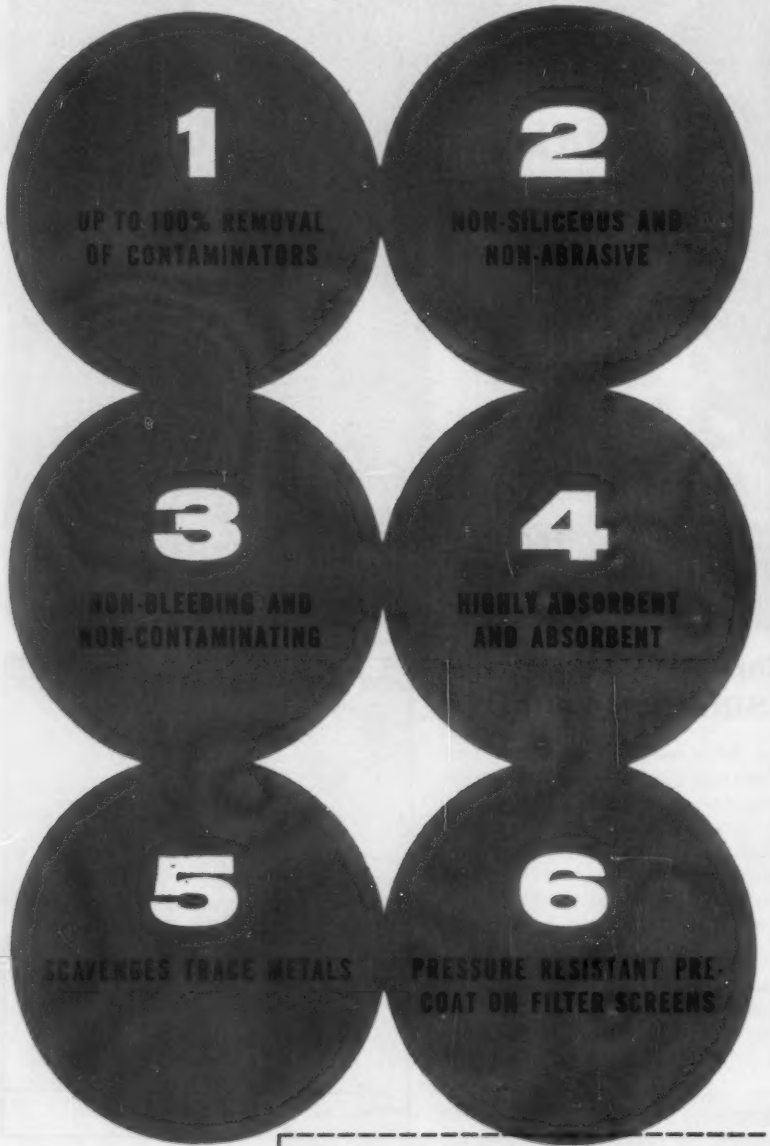
For more facts circle 261 on Reader Service card, p. 119

SOLVE CONDENSATE CONTAMINATION

with newest, super-efficient filter aid

SOLKA-FLOC®

High steam pressure condensate contamination is often a serious and trouble-causing problem. Solka-Floc, basically different than other filter aids, removes up to 100% of contaminators—metallic ions, suspended solids, emulsified oil. It provides effective and economical filtration.



Whether your operations are simple or complex—send for the important and complete story on SOLKA-FLOC.

Another Quality Product of FP80

BROWN COMPANY

150 Causeway Street, Boston 14, Mass.

Please send me your Solka-Floc folder.

COMPANY_____

NAME_____ TITLE_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

Free literature

Begins on page 119A

Electrical systems

- **Generation and transformation**

141 **Fuel cells,** how they work, problem areas, special features of ion-membrane fuel cell are covered in 12-p booklet available from the General Electric Company

142 **Distribution transformers,** insulated oil filled type, are topic of bulletin GEA-7047. New method of rating is described. General Electric Company

- **Distribution and protection**

143 **Control switches** are detailed in form 57-87. Automatic Switch Co

144 **Semiconductor** condensed catalog contains listings and basic specs of firm's complete line. Amperex Electronic Corp

145 **Arc inhibitors, application,** installation, dimensions, electrical characteristics are covered in 2-p brochure 9600. Square D Company

146 **Rigid-polyvinyl - chloride** electrical conduit is topic of 20-p catalog. Test results, specs, installation instructions are given. Kraloy Plastic Pipe Co, Inc

147 **H-v ac-dc testers** are covered in 4-p data sheet. Sorensen & Co

148 **Plug-in bus-duct** application data is available in 28-p booklet 30-661 from Westinghouse Electric Company

149 **Power - factor capacitors,** low- and high-voltage units used to correct plant power-factor deficiencies, are described in bulletins 8146 and 8147. Federal Pacific Electric Company

150 **Rotary-handle circuit breakers,** used in switchboards, control centers, panelboards, are topic of 8-p brochure 1425. Rating is from 15 to 800 amp. Federal Pacific Electric Company

151 **Fundamentals of splicing** and terminating rubber - neoprene cables are given in bulletin 1134. The Okonite Company

152 **Bushings** for transformer, circuit-breaker and special-purpose applications are described in 28-p catalog. Lapp Insulator Co, Inc

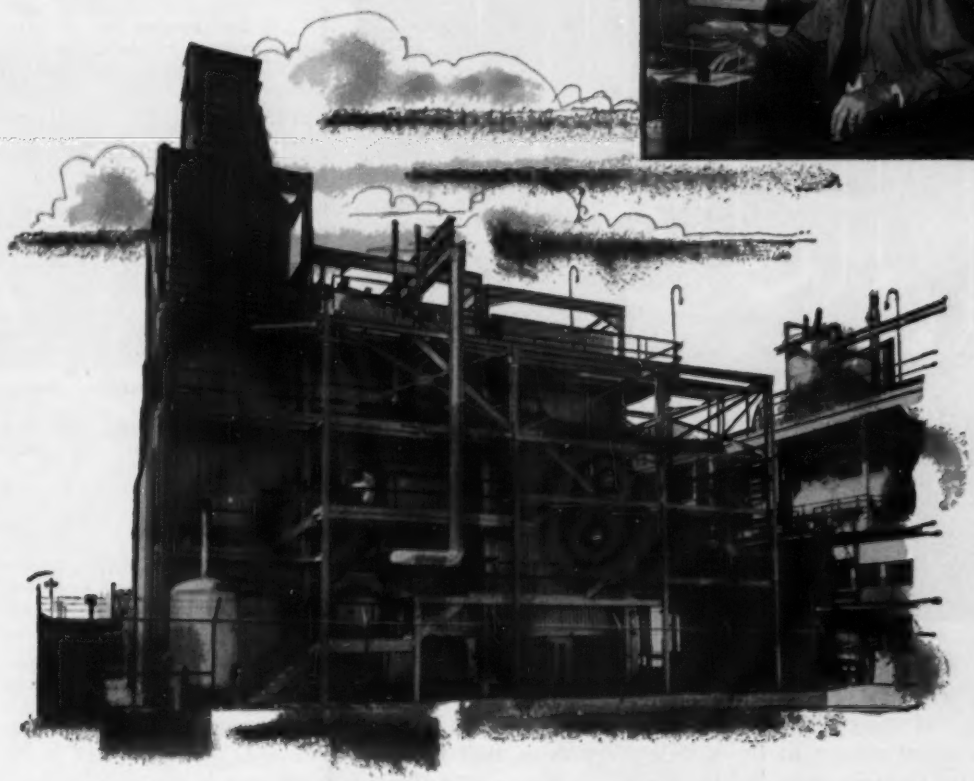
153 **Voltage regulator,** tubeless magnetic-amplifier type for ac generators or generator exciters are presented in 14-p booklet. Fidelity Instrument Corp

154 **Rigid steel conduit** with organic protective coating over a sherar-

NEW WICKES STEAM GENERATOR

insures maximum efficiency and dependability for BRYAN, TEXAS, MUNICIPAL POWER PLANT

Calvin W. Beard, Superintendent of the Electric Utilities of Bryan, Texas, Municipal System: "As in every other power plant, our steam generator must give completely dependable performance day in and day out".



This Wickes Type RB 2 drum boiler is designed to produce 220,000 lbs. of steam per hour at 875 psig and 900° total steam temperature for the city of Bryan, Texas. The unit performs not only with remarkable dependability, but with Wickes' usual efficiency and economy. Wickes Boiler Co. builds steam generators in sizes to 500,000 lbs. of steam per hour, for high or low steam pressures and temperatures and for all types of fuels and firing methods. See your nearest Wickes representative for full information on a Wickes steam generator designed to suit your needs.

WICKES

RECOGNIZED QUALITY SINCE 1854

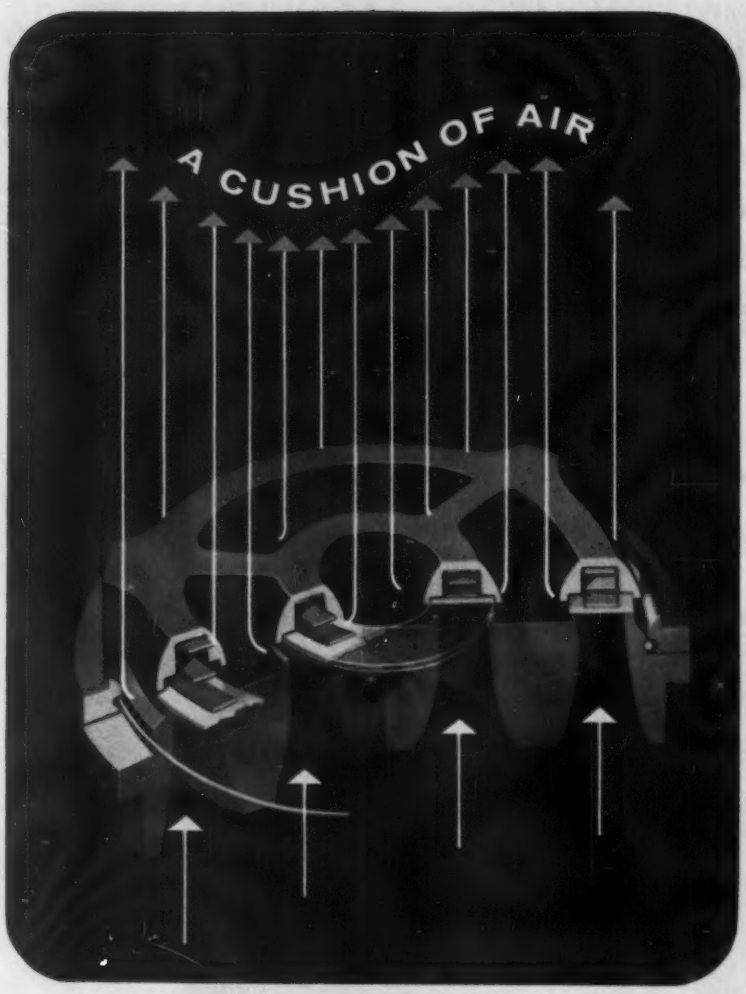
Sales Offices: Atlanta • Boston • Charlotte, N.C. • Chicago • Cleveland Dallas • Denver • Detroit • Houston • Indianapolis • Los Angeles • Memphis • Milwaukee • New Orleans • New York City • Philadelphia • Portland, Ore. • Rochester, N.Y. • Saginaw • San Francisco • Seattle, Wash. Springfield, Ill. • Tulsa

Bulletin 55-1 gives details of a wide variety of designs and sizes of Wickes field-erected and shop-assembled steam generators. Write for your free copy.

174

WICKES BOILER CO., SAGINAW 10, MICHIGAN, **DIVISION OF THE WICKES CORPORATION**

For more facts circle 263 on Reader Service card, p. 119



makes PENNSYLVANIA COMPRESSORS run efficiently...silently...with minimum maintenance. Stainless steel valve discs lift against a cushion of air in the simple, efficient design of the Air Cushion Valve that makes PENNSYLVANIA Compressors run so silently, so dependably, and with such low maintenance requirements. Air Cushion Valves have no nuts, bolts, or screws to break or burn fast. You get longer valve life . . . eliminate wear . . . eliminate noise caused by metal striking metal. Flat valve discs have no flexing or bending action to weaken or distort them; they remain perfectly flat and tightly seated over long periods of service.

But this is only part of the PENNSYLVANIA story. Learn all the facts in "Compressors For Industry." It describes PENNSYLVANIA Compressors from 10 to 350 hp, horizontal, angle, and OILFRE models. Write to Dept. A-7 for your copy today.

PENNSYLVANIA
PUMP AND COMPRESSOR COMPANY
Easton, Pa. • Earning Customer Confidence Since 1920

Free literature

Begins on page 119A

dized zinc surface, epoxy-resin base, is introduced in bulletin 360-C. Walker Brothers

155 **Motor - starter panelboards** and switchboards with circuit-breaker or fusible-switch disconnect devices — maximum 50 hp, 600-v ac—are topic of bulletin GEA-6728 available from General Electric Co

• Electrical application

156 **Cabinets** for electrical systems are detailed in product specification G71-6 available from Bailey Meter Company

157 **Footcandle-** and lighting-design booklet A-7235 is pocket-sized manual. Westinghouse Electric Corp

158 **Amplistats** and amplistat reactors are featured in 20-p bulletin GEA-6930. General Electric Co

159 **Battery chargers,** industrial type, are designed to automatically control charging. Details are in bulletins 236, 202. Automatic Switch Company

160 **Infrared** linear - source - section bulletin 59-240 gives pre-engineered modular oven components incorporating quartz lamps, tubes or metal rods as sources for infrared heat. Fostoria Corp, Infrared Div

161 **Ac-motor catalog** includes pricing and dimensional data for ¼- to 200-hp range, has 56 pp Special section covers motor selection and application. Sterling Electric Motors

Gas systems

• Air compressors

162 **Packaged centrifugal** air compressors for air-separation plants and industrial plants are presented in 20-p bulletin 175. Clark Bros Company

163 **Desiccant dryers,** heat - reactivated type, provide source of dry air or gas with dewpoints to −100 F. Bulletins A-309, AB-310 tell story. Trinity Equipment Corp

• Valves

164 **Throttle valves** for control of compressed - air or pneumatic-operating equipment are illustrated in 4-p bulletin 460. Hose Accessories Company

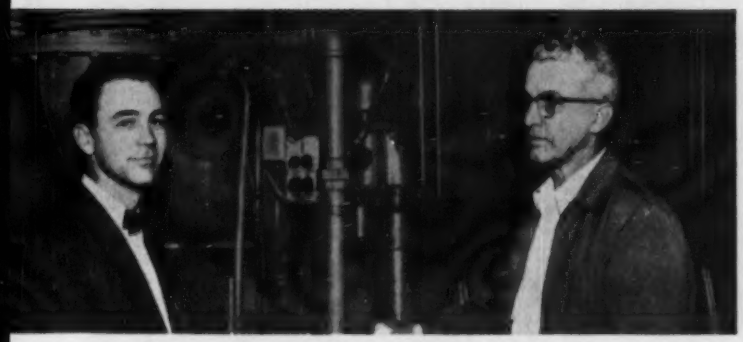
165 **Air - operated valves,** bellows sealed solenoid-controlled type,

For more facts circle 264 on Reader Service card, p. 119

circle 265 on Reader Service card, p. 119 ➤

Want minimum maintenance on a dual-fuel engine? —STANODIESEL Oil M

Stafford, Kansas Light Plant finds this lubricant helps hold down maintenance and operating expense



Bill Ray, (left), Standard Oil lubrication specialist calls on Stafford city superintendent LeRoy Priess. Rendering technical assistance to customers such as this is Bill's job. He is qualified for it through seven years' service with Standard Oil Company. Bill is a graduate of Wichita University.

Quick facts about
STANODIESEL Oil M

- Keeps crankcase, pistons, cylinder walls clean.
- Combats deposit and wear problems imposed by economy fuels.
- Maintains film on difficult-to-lubricate parts.
- Eliminates fuel injector and pump sticking caused by deposits on injector barrel and plunger where fuel and lube oil mix.

From February, 1953 to April, 1959 a 1,280 hp., 720 rpm., dual-fuel engine at the Stafford, Kansas Municipal Light Plant generated more than 12.5 million kilowatt hours in 29,780 hours of operation. At the end of this period the top piston rings were replaced; however, the amount of wear was almost too small to measure. Rings, pistons and cylinder walls showed only a negligible amount of carbon and varnish. Lube oil consumption was 7,399 gallons or 1,697 kw. hours per gallon.

You can get this kind of service with STANODIESEL Oil M. The oil's superior base stock, coupled with its additives gives you these maintenance and operating savings: low oil consumption, reduced port deposits, fewer stuck rings, less need for ring replacements, less cylinder wear, lower filtration costs and fewer bearing problems.

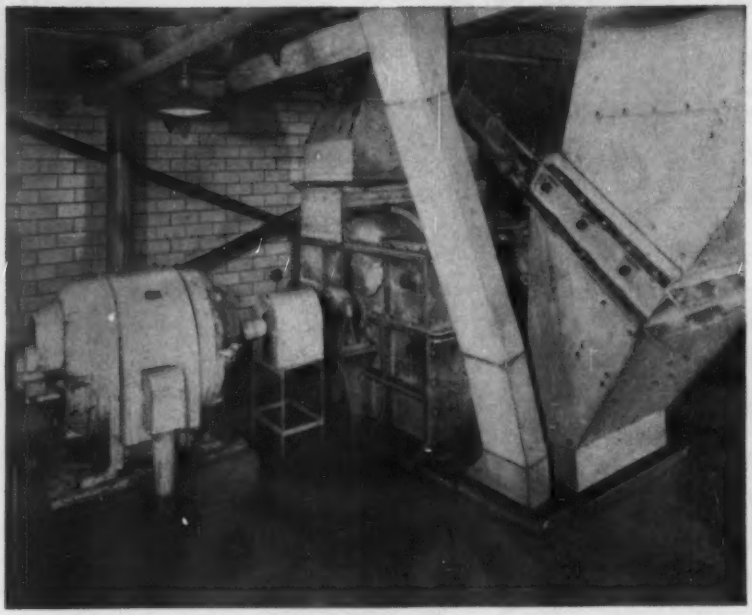
Learn more about STANODIESEL Oil M. Call the Standard Oil office near you in any of the 15 Midwest or Rocky Mountain states. Or write **Standard Oil Company (Indiana), 910 South Michigan Avenue, Chicago 80, Illinois.**

STANDARD

You expect more from STANDARD and you get it!

Piston after 29,780 hours. Virtually no carbon deposits or varnish are visible.

CRUSHING FACTS



American "Rolling Ring" Coal Crusher
splits coal . . . smashes maintenance costs!

In almost five years, the above American Coal Crusher has reduced 1,800,000 tons of 2" x 0" coal to a ¾" x 0" product for a prominent midwestern utility. Since installation, this unit has handled an average annual tonnage of 450,000, with a very low ratio of replacement parts to tonnage. The operating engineer for this utility says, "We have experienced no stoppages . . . crusher operation and maintenance have been very satisfactory."

"Rolling Ring" design makes the difference. Specially designed rotor, consisting of four rows of patented shredder rings, each suspended on a single shaft, rotate freely at a relatively *slow speed.* Coal is *split* rather than smashed. This splitting action saves both power and maintenance, gives more uniform sizing, fewer fines. Rings can be reversed to give extended life.

American has manufactured reduction equipment since 1908 and you can be sure that "When you figure costs, the best results come from American *Rolling Ring* Crushers." If you have a coal preparation problem, why not write today for recommendations and literature. Our highly-trained engineering staff will give you prompt assistance.

American PULVERIZER COMPANY
PIONEERS AND MANUFACTURERS OF RING CRUSHERS AND PULVERIZERS
1349 MACKLIND AVE. ST. LOUIS 10, MO.

Free literature

Begins on page 119A

are featured in spec sheet PV. Veeco Vacuum Corporation

- **Gas production and storage**

166 **Gas producers** prevent oxidation and decarburization during annealing, normalizing and hardening—covered in bulletin GED-3996. General Electric Company

167 **Handling, storing** and converting liquefied oxygen, nitrogen and argon — explanation of principles and techniques — available in booklet from Air Reduction Sales Company

168 **Ultra-high-purity gases,** properties, applications and storage are covered in 16-p brochure offered by Linde Company

Steam systems

- **Boilers**

169 **Packaged steam generators** with combination-firing capacities up to 60,000-lb steam per hr, pressures to 600 psi are covered in 12-p bulletin. E Keeler Co

170 **Waste-heat boilers** are topic of bulletin 1700. International Boiler Works Company

171 **Wall deslagger** for thorough cleaning of boiler, superheater and reheat-section walls is explained in 4-p bulletin 1066. Copes-Vulcan Div of Blaw-Knox Co

- **Fuels**

172 **Fuel - oil additive** 2 is ashless, nonmetallic, contains copolymer. Details are in 12-p bulletin FOA-2. E I Du Pont de Nemours Co, Inc

173 **Fuel-oil** 7D-24 conditioner with Disotrol helps prevent fireside accumulations. See 4-p brochure from Nutmeg Chemical Company

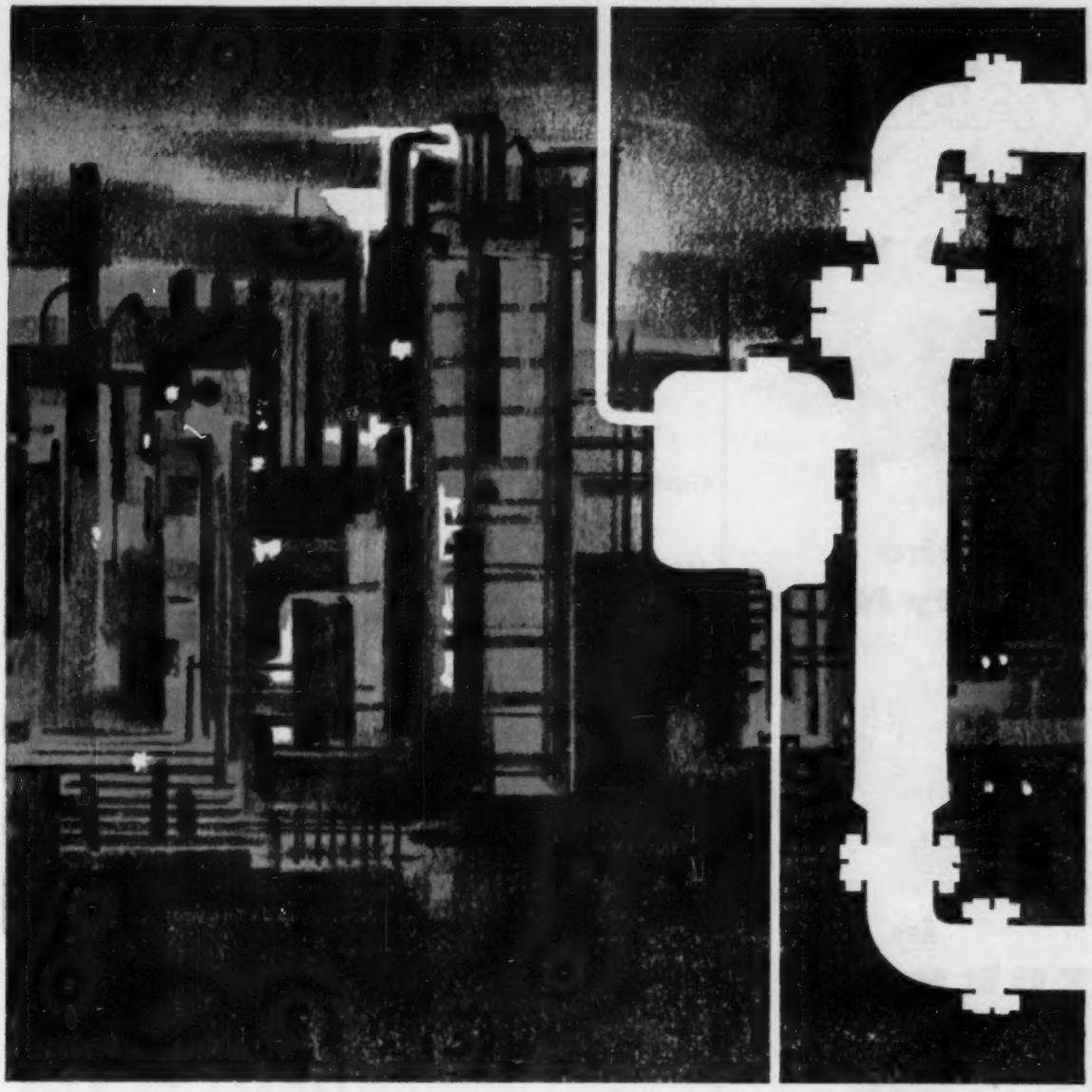
Mechanical transmission systems

174 **Fluid drives,** adjustable - speed type, are covered in 20-p bulletin A-79. Principle of operation and typical applications are described. American-Standard, Industrial Div

175 **Instrument drives,** flexible shafts, geared adapters are some of equipment included in 12-p booklet available from Actuator Products Corp

176 **Variable-speed sheave,** multiple-groove V-belt type, is presented in 8-p brochure 6102. T B Wood's Sons Company

continued



Fisher Level-Trols—universally accepted in the power and process industries

High in sensitivity and accuracy! For full float range operation the Fisher Level-Trol is factory calibrated or zero adjusted to produce an accurate 3 to 15 psi or 6 to 30 psi signal output. Designed, engineered and universally accepted for most liquid level control, liquid level indication and interface control problems. Has simple liquid level adjustment indicating dial—combined pneumatic proportional band and specific gravity adjustment. Heavy-duty built—easy to operate—simple to service. Available with cage units for external mounting or internal top or side flange mounting with float sizes from 14" to 120".

Write for Bulletin F4A for full details.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD... CHANCES ARE IT'S CONTROLLED BY...

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / London, England

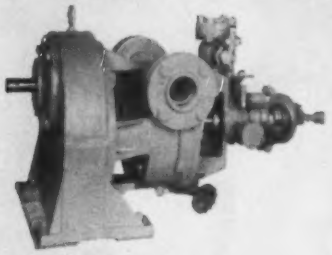
FISHER® Controls

SINCE 1880

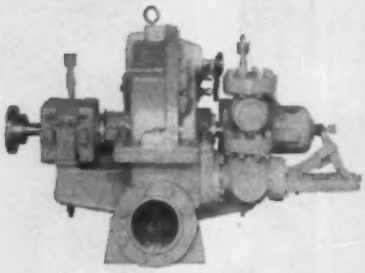
For more facts circle 267 on Reader Service card, p. 119

CARLING

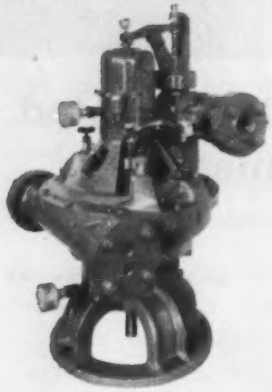
For 40 Years



the Quality Name



in TURBINES



WRITE FOR BULLETIN 20—C-3

CARLING TURBINE BLOWER CO.

7 NEBRASKA ST., WORCESTER, MASSACHUSETTS

Representatives in Principal Cities

circle 268 on Reader Service card, p. 119

Free literature

Begins on page 119A

177 **Bearings** with cylindrical roller are featured in catalog PT-659. Rollway Bearing Company

178 **Molded V-belts,** jacketed and notched, are covered in 4-p catalog M220. Raybestos-Manhattan, Inc. Manhattan Rubber Div

179 **Gear and bearing lubricants** are described with performance and characteristics covered in 8-p brochure. Lubrication Engineers, Inc

Liquid-handling systems

- **Water treatment**

180 **Solids-contact reactors** for water clarifying and softening are covered in 20-p publication 5001-C. Types and designs of reactors are illustrated. Cochrane Corp

181 **Eliminating water waste** with controlled pressure is topic of 4-p brochure 553-A. Leslie Co

- **Pumps**

182 **Pumping equipment** for handling waste materials is described with specs and aplications covered in bulletin 2305. Yeomans Brothers Comany

183 **Mechanical vacuum pumps** have specs, operational data charted in folder S-15. Consolidated Vacuum Corporation

184 **Submersible pumps** used as booster pump in municipal water systems are discussed in bulletin B-1200. Pumps are rated up to 125 hp and have capacities up to 3300 gpm. Sumo Pumps, Inc

185 **Rotary pumps** change displacement to vary delivery from zero to full capacity while running at constant speed; they reverse flow to evacuate discharge lines after shutoff. Specs and application data are in 8-p bulletin 600. Blackmer Pump Co

186 **Centrifugal** and turbine type pumps, single and multi-stage units, are detailed in well-illustrated 4-p folder. New York Air Brake Company, Aurora Pump Div

- **Controls**

187 **Valve permits draining** water from bottom of storage tanks, won't freeze. Bulletin 500-2-1 tells the story. The Johnston & Jennings Co

188 **Bronze-solder-joint valve** is topic of revised 4-p folder. Instructions

REMOVE OXYGEN FROM BOILER WATER...

DEOXY-SOL

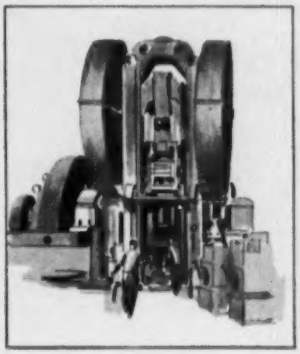
Fairmount DEOXY-SOL, a solution of hydrazine, is a high efficiency oxygen scavenger designed especially for high pressure boiler water treatment.

DEOXY-SOL removes oxygen, reduces oxides and raises pH of the condensate all at the same time . . . yet adds no solids.

Stocks in Newark, N. J., Chicago, Ill., Los Angeles, Calif. Investigate its advantages for your system. Write for Bulletin BW.

Fairmount CHEMICAL CO., INC.

circle 269 on Reader Service card, p. 119



KILBYSTEEL Announces

- THE FIRST MECHANICAL TUBE EXTRUSION PRESS IN AMERICA
- THE LARGEST AND FASTEST IN THE WORLD
- THE WORLD'S ONLY SEAMLESS MILL EMPLOYING EXTRUSION AND THREE ROLL REDUCTION

NOW PRODUCING

CARBON AND ALLOY SEAMLESS STEEL TUBES

OF INHERENT SUPERIOR QUALITY

1 SMOOTH INSIDE SURFACE
Round Billet is Pierced Around Precision-Ground Sliding Mandrel *Versus* Stationary Plug Piercing.

2 ACCURATE CONCENTRICITY
Mechanically Guided Piercer *Versus* Floating Plug Piercer.

3 UNIFORM WALL THICKNESS
Three Roll Size Reduction *Versus* Two Roll Reduction.
50% More Roll Pressure Points
50% Less Chance of Variation

4 IMPROVED PHYSICALS
Instantaneous Extrusion Impact *Versus* Prolonged Spiral Rolling.
Approximately Equal Transverse and Longitudinal Properties, resulting: Higher Tube Hoop Strength.

5 FAST PIERCING AND REDUCTION OF HARDEST STEELS
Extrusion Speed Rates up to 25 Feet per Second *Versus* Tedious Plug and Roll Piercing.

Elapsed Time from Billet to Hot Finished Tube, 33 Seconds *Versus* Reheating and Reduction.

SIZES UP TO 3½" O.D.

K Blue Bonnet S
OIL WELL TUBING

KILBY STEEL COMPANY
ESTABLISHED 1889
ANNISTON, ALABAMA
P. O. Box 1489 Cables: KILBYSTEEL Phone ADams 7-2841

K seamless S
QUALITY TUBES

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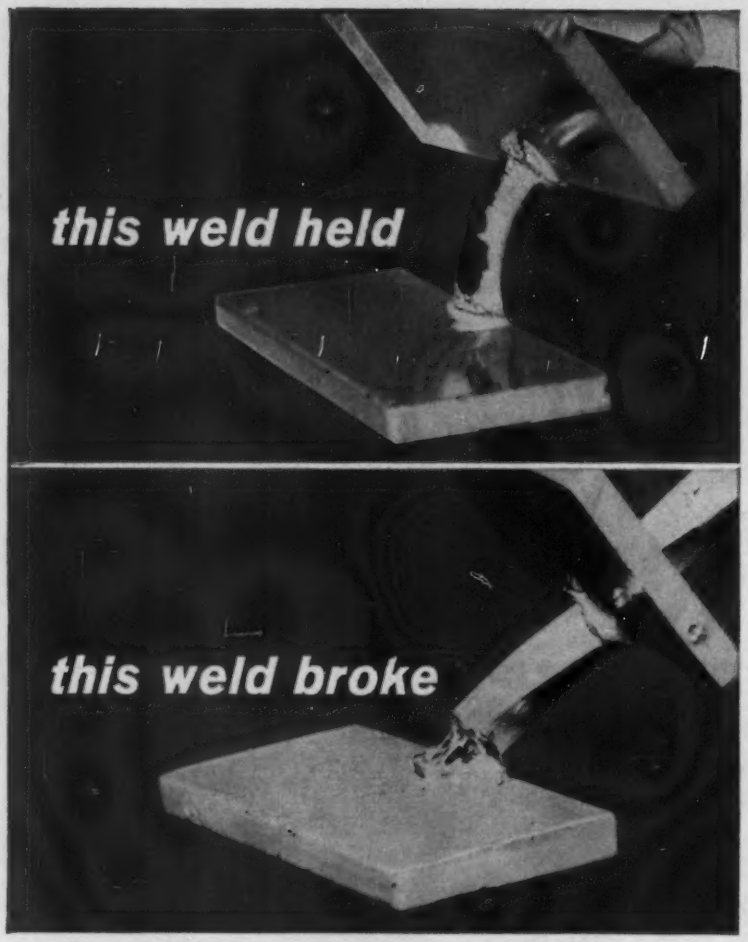


(Above) This DRAVO TRU-WELD GRATING was deliberately bent, placing far more strain on the welds than there would be in normal service. Not a single weld has parted. This grating will withstand vibration and hard usage.

(Below) Bent in exactly the same way, this grating came apart at the welds. The fusion of bearing bar to cross bar achieved by the Dravo method of manufacture prevents this from happening to Tru-Weld Grating.

the new stronger grating is TRU-WELD

Tru-Weld grating is stronger because it is *made* that way. Its added strength comes from a manufacturing process that completely fuses the metal at cross bar-bearing bar joints and holds the bars to exact spacing. The result is grating that stands up under excessive vibration, heavy traffic or in areas where corrosive fumes and moisture are a problem. And Dravo Tru-Weld grating *costs no more.*

Complete estimating, layout and fabricating services are available. Immediate delivery from stocks maintained at nearby Joseph T. Ryerson Service Centers will help you meet exacting construction schedules.

For more information on this new, stronger grating — call the Dravo representative in your area, or write Dravo Corporation, Pittsburgh 25, Pa.

DRAVO CORPORATION

Free literature

Begins on page 119A

on how to make a sound solder joint are given. Walworth Co

189 **Strainer guide** has 33 pp, over 100 illustrations of pressure drop, temperature, viscosity charts based on tests, engineering drawings. Info on fluid-flow-system layouts and strainer sizing along with tabulated test results, valve and pipe selection are included. Tate Engineering, Inc

Nuclear systems

- **Atomic-energy facilities**

191 **Design and construction** of reactors, resources and firm's services are covered in booklet 43B9541. This specifically treats research and production facilities devoted to atomic-energy problems. Allis-Chalmers Mfg Co

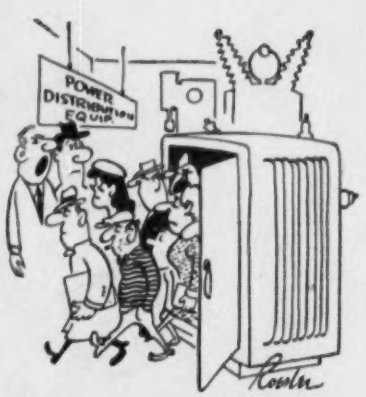
192 **Fifth anniversary** of firm's commercial atomic progress is celebrated in booklet describing applications of atomic energy. General Electric Company

- **Instrumentation**

193 **Proportional counting** systems for alpha and beta activity in prepared samples are featured in 16-p bulletin. Nuclear Measurements Corp

194 **Firm's complete line** of nuclear instruments and instrumentation-system-design services are outlined in 4-p bulletin GEA-7006A. General Electric Company

195 *How to cut your reading* time is topic of 12-p handbook. Both speed and comprehension are covered, exercises included. *$1.25,* Developmental Research Institute, Inc



"This is a subway transformer".

Quality costs less in the long run

"BLUE RIBBON" boiler feed pumps for every application . . .

Demands for higher pressures and capacities in modern boiler feed pumps have also created a need for higher speeds and greater reliability.

And in boiler feed pumps – as in every other type of centrifugal – Byron Jackson can match any requirement with a quality, performance-proved pump.

From direct turbine-generator driven models, such as the giant 12,000 horsepower, 3,600 rpm unit above, to the compact, 15,800 rpm marine boiler feed pump shown at the left, BJ designs are inherently reliable. Built-in balance, minimum NPSH requirements, and simple, effective sealing are common to all BJ Quality Pumps for the power industry.

Quality *does* cost less in the long run!

Byron Jackson Pumps, Inc.

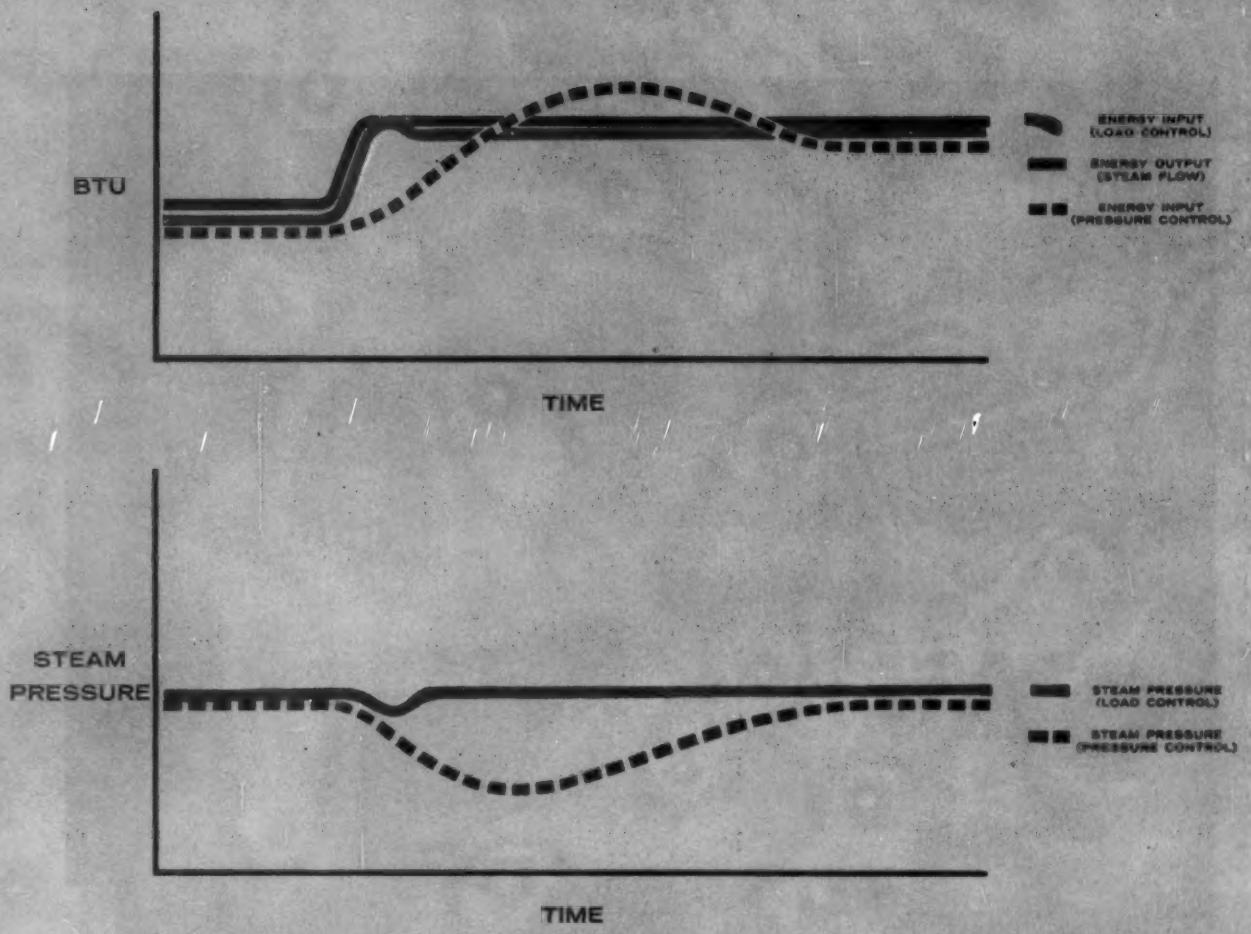
subsidiary of Borg-Warner Corporation

P.O. Box 2017A, Terminal Annex, Los Angeles 54, Calif.

BJ

Since 1872

For more facts circle 272 on Reader Service card, p. 119



Republic's patented electronic load control system quickly establishes new firing condition and rate of feedwater flow. Note that steam pressure varies a relatively small amount and for a short interval. Electronic load control establishes new energy levels much faster than steam pressure control systems. This high speed control results in improved stability and safety. Steam pressure is more accurately controlled, and a more efficient fuel-air ratio is maintained.

Republic Electronic Load Control Gives

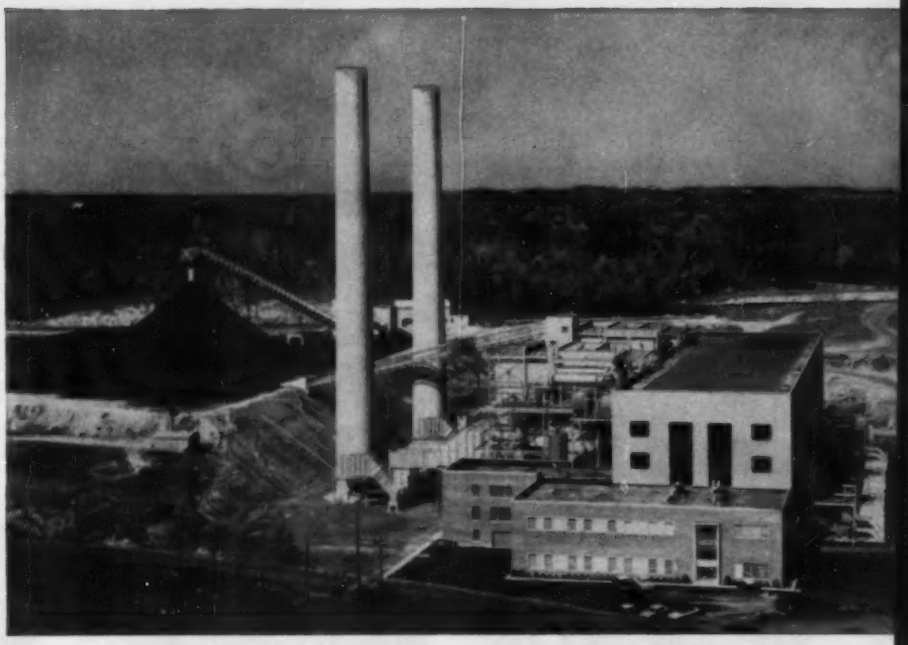
Republic patented electronic load control instantly proportions fuel flow, air flow, and feedwater flow to a precise measurement of unit load. The moment a turbine steam inlet valve setting changes, Republic's load control changes the firing rate—long before steam pressure can vary. Minor pressure variations due to inaccuracy of fuel measurement impose a final adjustment to return steam pressure to the set point. Correct steam pressure is quickly restored because these small deviations from set point require proportionately short intervals for correction. Pressure swings are practically eliminated.

Accurate Control of Fuel-Air Ratio. Electronic load control makes it practical to control air flow directly from energy output or total steam flow. Fuel flow changes immediately with a change in steam flow, and only final trimming of fuel from steam pressure is required. The time interval between air flow change and fuel flow change is insignificant. Thus, with fuel flow and air flow changing simultaneously, air flow is proportioned directly to steam flow, and safe, accurate control of fuel-air ratio is maintained.

More Stable Feedwater Control. Feedwater flow is proportioned to the master load signal from the Republic load control system. It is also modulated by the drum water level. This provides the final minor correction that maintains the drum water level at the setpoint without excessive controller action.

LOWEST BTU INPUT PER KWH

Silas C. McMeekin Station of South Carolina Electric and Gas Co., established a fine record of 9,093 BTU input per net KWH output, according to the latest Federal Power Commission Report. Equipped with a Republic electronic combustion and load control system (central control room shown above), the new McMeekin station (right) has a capacity of 250 MW with its two 910,000 lb/hr boiler systems.



Faster Response, Greater Efficiency

Improved Steam Temperature Control. Under load control, under-firing and over-firing are greatly reduced because firing rates are quickly matched to energy output. The fuel air ratio is accurately controlled. Combustion gas flow and temperature are maintained at boiler design levels, minimizing the correction required of the steam temperature control equipment.

In Duty Since 1949. Republic pioneered electronic combustion controls with the first such system installed in Commonwealth Edison's Ridgeland Station in 1949. More than 125 Republic electronic combustion control systems have been installed totalling more than 400 unit years of operation.

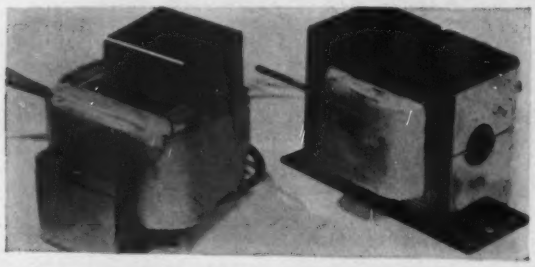
Republic patented electronic load control is typical of Republic engineering leadership for over 50 years. Let a thoroughly experienced Republic sales engineer help you with your instrument and control problems. Contact your nearest Republic representative, or write Republic Flow Meters Co., 2240 Diversey Parkway, Chicago 47, Illinois. In Canada: Republic Flow Meters Co., Ltd., Toronto, Subsidiary of Rockwell Manufacturing Co.

REPUBLIC INSTRUMENTS AND CONTROLS
more fine products by
ROCKWELL

For more facts circle 273 on Reader Service card, p. 119

For more data on these developments, circle key numbers on Reader Service card, p 119

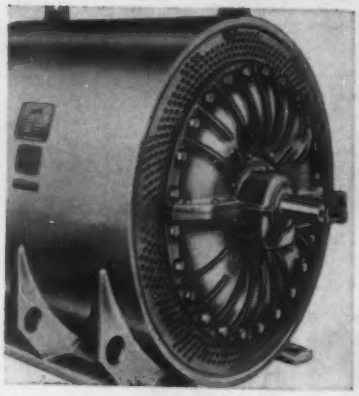
Plant equipment news... Your



Transformer-core design gives greater flexibility

1 • Smaller and lighter transformer does same job as conventional units but uses cores nested together to reduce magnetic circuit's resistance. U-shaped cores are simple and will fit into already-designed equipment and systems. According to manufacturer, this smaller transformer may permit designing more compact electrical equipment without having to change equipment's operating characteristics.

Transformer core consists of laminated nests of steel strips fabricated from a continuous roll. Each core has two U-shaped nests of strips which fit together by meshing strip tops. Result is a hollow square or other shape, left. Coils and leads have been added to transformers, above. Unit on right has nested laminations secured by welds.—Sylvania Electric Products, Inc

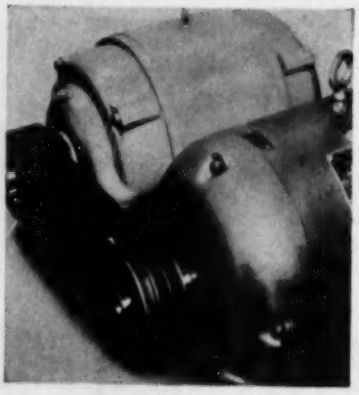


Tube-cooled motors built for trouble areas

2 • Heat-exchanger motors are especially suited for unfavorable conditions—they protect against excessive moisture, oil, vapor, chemicals, coolant and air-borne dust, dirt and metallic particles. Units range to 2000 hp and are constructed for hazardous or nonhazardous locations. Applications suggested by the maker are for pumps, compressors, conveyors, fans and blowers, special industrial machinery.—The Louis Allis Company

Epoxy insulates 1- to 500-hp motors

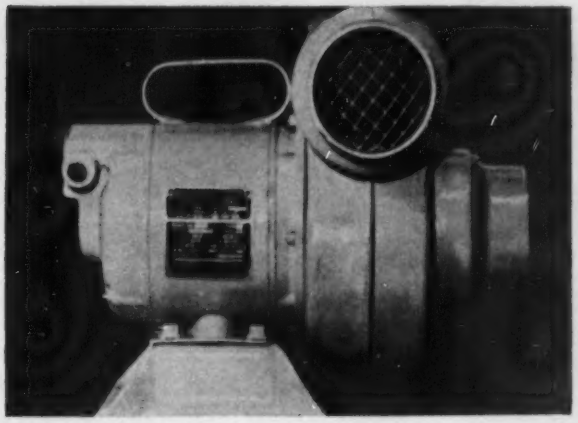
3 • Electric-motor-coil insulation can be applied to random-wound and form-wound motors with high-hp ratings. For latter type, epoxy resin is applied to core and frame before winding. Then Epa-Seal vacuum-pressure process impregnates entire wound stator. Random-wound motor, above, has entire stator encapsulated by vacuum-pressure system which drives epoxy resin into all coil slots. —Elliott Co, Crocker-Wheeler Div



Brushless alternators for 400 cycles, to 15 kva

4 • First unit of brushless line covers 1- to 15-kva range, is equipped with transistorized voltage regulator. Maker claims device provides more power on smaller frame (15 kva on 256 NEMA). Solid-state exciter voltage regulator was specifically designed for alternator. It uses semiconductors and highly stable voltage reference to provide a virtually drift-free all-static device. Cooling system is included.—Leach Corp, Inlet Div

information center for new products and materials



Portable pressure blowers are compact, lightweight

5 • Units were designed for ventilating—they remove fumes and dust, furnish fresh air for confined work areas—or supplying air under static pressure to boilers. They're waterproof and vaporproof.

Thermally protected ¼-hp motor is totally enclosed. It's aluminum to prevent sparking and resist corrosion. Unit delivers 435 cfm of free air or 250 cfm at 2-in. static pressure, may be operated in any position without efficiency loss.—Manhattan Electric and Maintenance Co

Static generator powers dust-shattering air-cleaning system

6 • Compact generator provides h-v static electricity for 10,000-cfm air flow. It's made especially for Stratonic system of dirt and dust control. Generator supplies screens with energy necessary to bombard dirt and dust particles in air, exploding them into bits well below 0.1 micron—a size so small particles stay suspended in the atmosphere. Weight is 30 lb.—CRS Industries, Inc

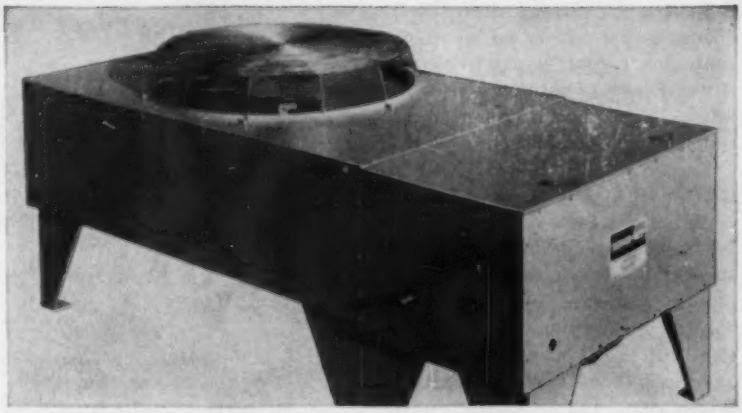
Simplified analyzer

7 • Analgraph needs no chemical reagents or training to operate in connection with oxygen, carbon-dioxide and carbon - monoxide combustion tests. In minutes, according to maker, gas analyzer quantitatively determines combustible gases and vapors. Unit is particularly suited for chemical-process work and leak detection.

You can sample continuously. Alarm system can be provided to warn of either oxygen deficiency or combustible vapors. Unit is simple with no electronics involved. — Gas Purifying Materials Co, Inc

Condensing unit—water saver for air conditioners

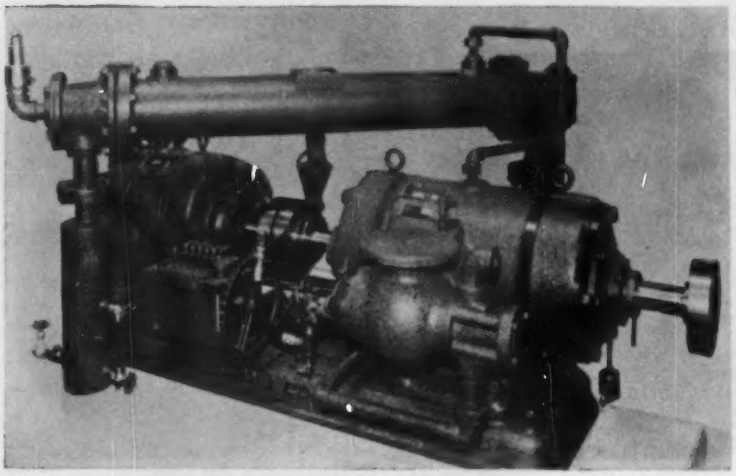
8 • Low-silhouette condensing unit in 10- to 30-ton sizes is specifically for air - conditioning applications. Blower condenser is standard with motor compressor, liquid receiver, electrical controls and refrigeration accessories which can be remotely installed. Enclosures are designed for outdoor use, easy maintenance. Air movement is up and out, keeping noise at a minimum, air flow away from buildings.—Dunham-Bush, Inc



For more data on these developments, circle key numbers on Reader Service card, p 119

More **equipment news**

For more data on these developments, circle key numbers on Reader Service card, p 119



Two-stage rotary compressor comes assembled

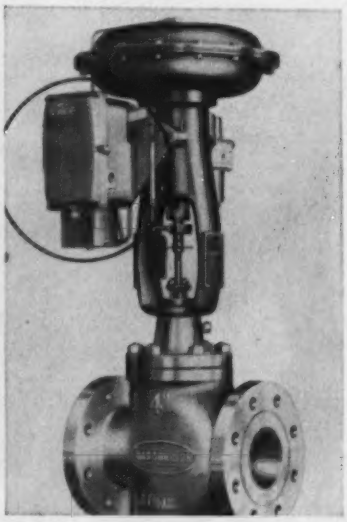
9 • Compact compressor is specifically designed to simplify installation and foundation problems, maker says. Unit will operate either on floor or mezzanine. All you have to do at installation scene is add motor, air and water piping. Small number of parts cuts maintenance time and costs.

Compressor line covers capacities from 279 to 3300 cfm and discharge pressures to 125 psi. You can make connections directly to electric motors, gas motors or gear-turbine drive. Overhead cooler feature makes unit more compact. Intake and discharge openings are in horizontal plane on opposite sides of cylinder, to avoid air-flow reversal.—Fuller Company

Positioner controls, throttles like a valve

10 • Electropneumatic positioner combines advantages of electronic controllers with power and throttling action of pneumatic control valves. A true positioner, device directly compares valve-stem position with controller output signal. For fast stroking speed, positioner uses air relay; large magnetic-force motor supplies high-force changes.

Simply installed and requiring little maintenance, unit is for 3-to-15- or 6-to-30-psi valve-spring ranges or for split ranging. You can adjust stroke through a plate-covered aperture without exposing wires, install valve in any position without calibration shift. Relay may be mounted in any position to facilitate piping.—Worthington Corp, Maison-Neilan Div



Metering pump, ruggedly built, is simple in design

11 • Pump can be used for many metering applications, is particularly suited for handling slurries and viscous liquids of all kinds, says maker. Pump is ruggedly constructed; its simple, compact design permits moderate pricing.

Operating parts should give good service. Gear case and pump body are flanged together and completely sealed against moisture and dirt. Motor pad is bolted in permanent alignment with shaft—no packing glands. Capacities range from 0 to 10, 18, 36, or 54 gph, pressures to 300 psi. —The Madden Corp

Aluminum alloys combat h-t steam, water corrosion

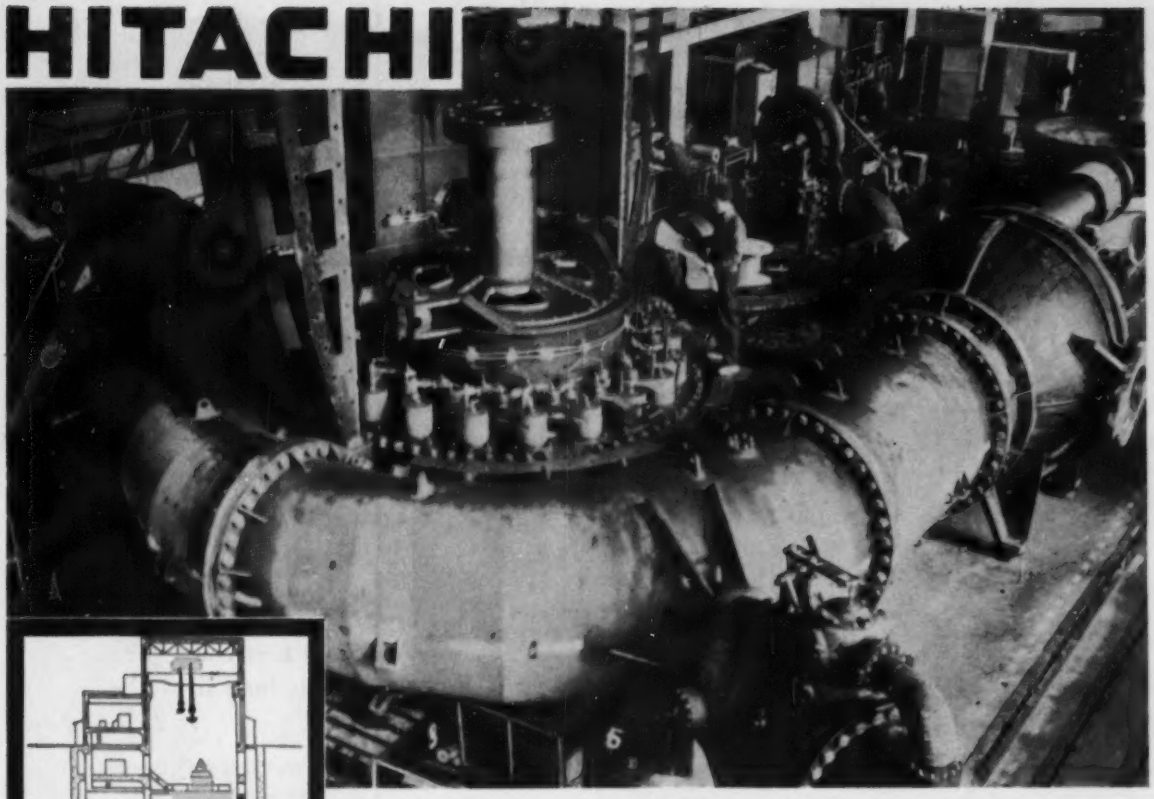
12 • Aluminum-iron-nickel alloys withstand deteriorating effect of high-purity water to 680 F, were tested in both wrought and aluminum-powder metallurgy forms. Latter form contains 4.81% iron, 7.03% nickel. During tests, this composition registered least susceptibility to corrosion. Slight corrosion which occurred diminished quickly to point defying detection, says maker. Alloys may eventually be used for cladding atomic-reactor uranium fuel rods.—Aluminum Company of America

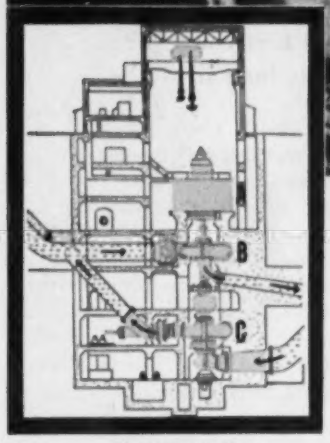
Cathodic protection goes automatic

13 • Control automatically adjusts current according to corrosion rate. It continuously indicates state of submerged structure and retards coating deterioration, maker claims. While conserving power and anode material, control keeps dc rectifier from overloading. Visual and audio alarms protect against system's malfunction. Applications include pipeline, condenser-waterbox installations. — Electro Rust-Proofing Corp

continued

HITACHI



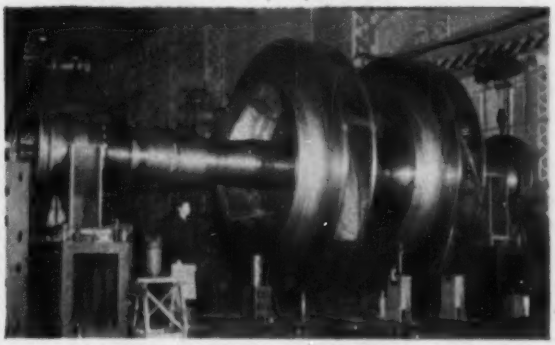


A Generator-Motor
B Turbine
C Pump
▼ Pump Impeller

Pump and Turbine Completed for the Huge Pumped Storage Power Station

Hitachi, Ltd. has recently completed a mammoth vertical shaft 56,500 kW turbine pump for delivery to the Morozuka Pumped Storage Power Station in Japan to surpass world level in this field. This turbine pump is scheduled to be installed with a 58,000 kVA/56,500 kW generator-motor and a 53,000 kW turbine, also of the Hitachi make.

This pump is to be operated on surplus power when it becomes available on such occasions as rainy seasons or midnight operations for pumping up water to the reservoir. The water stored this way is used to increase power output of the station in the peak-load period.



Hitachi, Ltd.
Tokyo Japan
Cable Address: "HITACHY" TOKYO

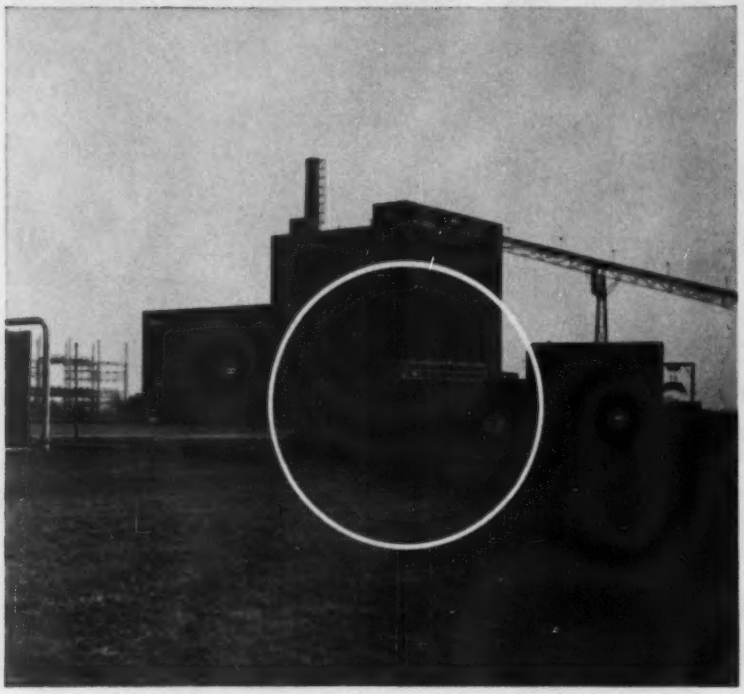
The Specifications of the various parts are as follows:

Pump	Quantity	18.6 m^3/s	**Generator-Motor**	Output	58,000 kVA (Generator)
	Total Head	241.4 m			56,500 kW (Motor)
	Speed	300 rpm		Voltage	11,000 V
Turbine	Effective Head	222 m		Current	3,045 A
	Output	53,000 kW		Frequency	60 cycles
	Speed	300 rpm		Speed	300 rpm

Beside the above, Hitachi, Ltd. also made and delivered automatic operational control equipment, transformers, switchboards, A.C. circuit breakers, overhead travelling cranes and other equipment for the Morozuka Power Station.

For more facts circle 274 on Reader Service card, p. 119

FLUIDICS* AT WORK



Permutit Precipitator treats sewage effluent to provide cooling-tower make-up water at the Municipal Electric Lighting & Power Plant, Richmond, Ind. Consulting engineers: Black & Veatch of Kansas City, Mo.

Consider sewage effluent as a second source of cooling water

Problem: This generating station needs plenty of water for its cooling tower. The river supply fluctuates. It must be augmented.

Solution: Working together, the Municipal Electric Lighting & Power Plant, Richmond, Ind., and its consulting engineers came up with a potential 7,000,000-gallon-a-day additional source: the city's sewage-plant effluent.

Now there's no question about water supply—even in the future, when the plant reaches its ultimate design capacity of 150,000 kw. Cooling-tower make-up may now come from the river, from the waste effluent, or be a mixture of both.

How? To turn sewage-plant effluent into usable cooling-tower water, you must stabilize the water and remove turbidity. Clarify, stabilize, give it the right chemical characteristics—process it in large quantities at low cost.

The Permutit Precipitator® you see in the picture above does this job. It was chosen because of its unique solids-contact features, which insure complete treatment at economical installed and operating cost.

Bulletins available: Operating details on Permutit Precipitators are contained in Bulletin 2204. Also available: "Outline of Water Treatment Equipment," Bulletin 4433, and our waste-treatment guide, Bulletin 4486. For copies, write to: Permutit Division, Dept. PO-80, 50 West 44th Street, New York 36, New York. In Canada, the Permutit Company of Canada, Ltd., 207 Queen's Quay West, Toronto, Ontario.

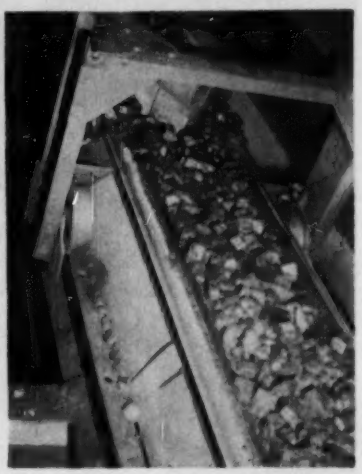
*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.

PFAUDLER PERMUTIT INC.

Specialists in FLUIDICS . . . the science of fluid processes

Equipment news

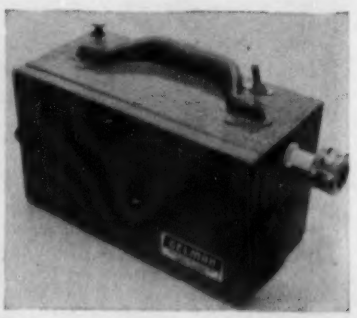
Begins on page 134



Steel belt conveyor boasts long life

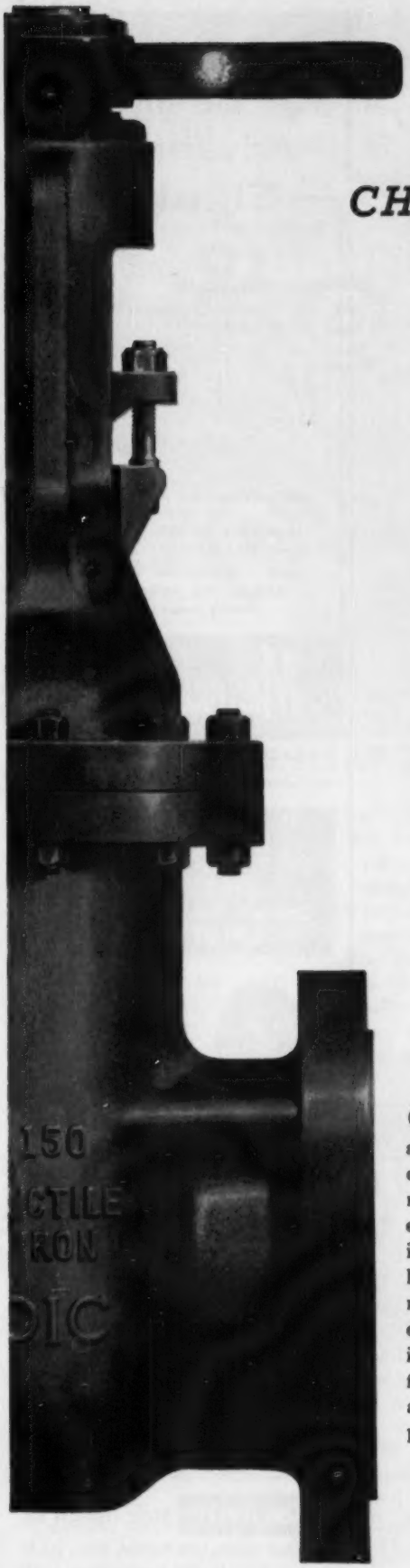
65 • Belt is a strip of carbon steel trued and flattened for conveyor applications. According to maker, its major advantages in handling coal are long life and ease with which coal is scraped from hard, smooth surface (life expectancy: about three years). Movable, plow type scraper discharges coal from belt to furnace. Belt is 16-in. wide, .036-in. thick.—Sandvik Steel Belt Co

Just circle key numbers on the Reader Service card, page 119, to get complete product story



Sampler speeds dust surveys

72 • Sampler weighs nine lb, samples air at rate of two cfm, filling need for lightweight, portable unit with high capacity. Centrifugal carbon-vane pump requires no lubrica-



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QUALITY and a reputation for quality are not easily attained in the valve business. At OIC we've worked for more than three-quarters of a century, with one unbroken chain of ownership-management, constantly guarding our standards of quality in materials, design, engineering, craftsmanship, and inspection. This long-standing reputation is reflected in the caliber of your nearby OIC distributor . . . a "quality house" with its own highly valued reputation. When you need valves and must be certain of quality, sight unseen, it will pay to phone your OIC distributor. He carries a representative stock of OIC bronze, iron, ductile iron, cast and forged-steel valves . . . and he can get 4 to 5-day delivery from OIC's warehouses or factory inventory. Since quality is a "must," and delivery is urgent, phone your OIC distributor. Quality products and prompt service are his business, and ours.

OIC VALVES

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THE OHIO INJECTOR COMPANY • WADSWORTH, OHIO

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VIBRATION AFFECT YOU?

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VIBRATION CONTROL

Solves your Vibration and Noise problems with . . .

ANALYSIS

Proper analysis is the first step to satisfactory Vibration Control. Trained personnel utilizing electronic vibration analyzers detect source of vibration and determine corrective action.

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Rotating machinery and parts are dynamically balanced to eliminate source of vibration and prevent poor equipment performance and damage to machine components from fatigue and stress.

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Mountings are installed to isolate vibration and noise which causes damage to structures and other equipment and operations, as well as human fatigue and discomfort.

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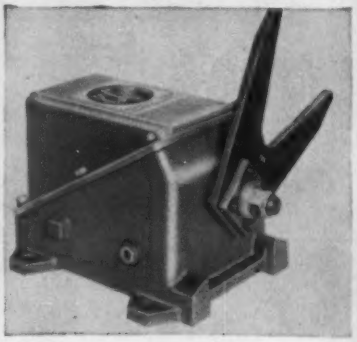
circle 277 on Reader Service card, p. 119

Equipment news

Begins on page 134

tion; built-in fan and louvered metal case provide air circulation to keep pump cool.

Sampler has open filter holder which connects to pump by polyethylene press-fit coupling. It's primarily for survey work where it will be used for an 8-hr working day. Sampler works on 110-v ac, 6-, 12- and 14-v dc.—Gelman Instrument Company



Limit switch for high-speed applications

81 • Heavy-duty limit switch for travel speed applications as high as 1200 ft per min features forked operating lever of high - impact - resistant plastic. Material will not damage operating bar and its resilience reduces shock to interior parts of switch. Switch works indoors and outdoors.—Square D Co, EC&M Div

Just circle key numbers on the Reader Service card, page 119, to get complete product story

Back-up rings increase O-ring life

94 • Continuous backup rings for O-ring groove installations are low in cost, quickly and easily installed, according to manufacturer. Rings have concave shape to prevent extrusion and increase lubrication of O-ring. Without spirals or cuts, 1-piece rings won't cut O-rings with worn backups or improper installation. They stand temperatures from –85 to 350 F, resist practically all fluids, gases and air.—Parker Seal Co

3 Distinct Design Advantages Eliminate

Costly Flow Failures with

Quick Operating
Non Sticking
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Magnatrol SOLENOID VALVES

Attain dependable, accurate, automatic or remote control of liquids or gases with MAGNATROL VALVES.
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Babbitt
Adjustable SPROCKET RIM
with Chain Guide
Changes that Danger Zone to a SAFETY ZONE

The distance between the floor of your plant and your overhead valves is a DANGER ZONE when pile up boxes or even ladders are used to reach the valves.
Turn it into a SAFETY ZONE — equip your overhead valves with Babbitt Adjustable Sprocket Rims with Chain Guides.

- They simplify pipe layout.
- They fit any size valve wheel.
- They are easy to install and operate.
- They operate any valve from the floor.
- They save time and money.
- The first cost is the only cost (no maintenance).
- They are packed completely assembled (one to a carton), with easy-to-follow instructions.
- A hot-galvanized rust proof chain is available for all sizes.

Babbitt Adjustable Sprocket Rims with Chain Guide are carried in stock by most mill supply houses. If your supplier does not carry them, contact us direct.

Babbitt STEAM SPECIALTY CO.
2 Babbitt Square, New Bedford, Mass., U.S.A.

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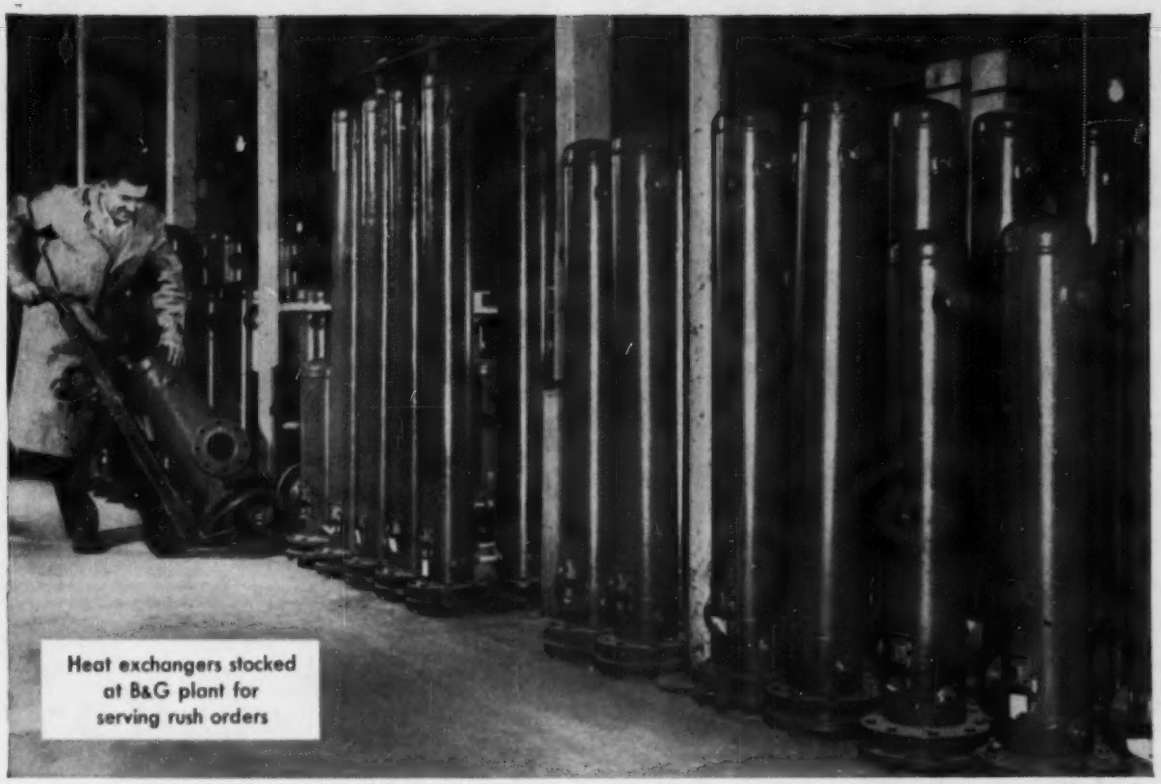


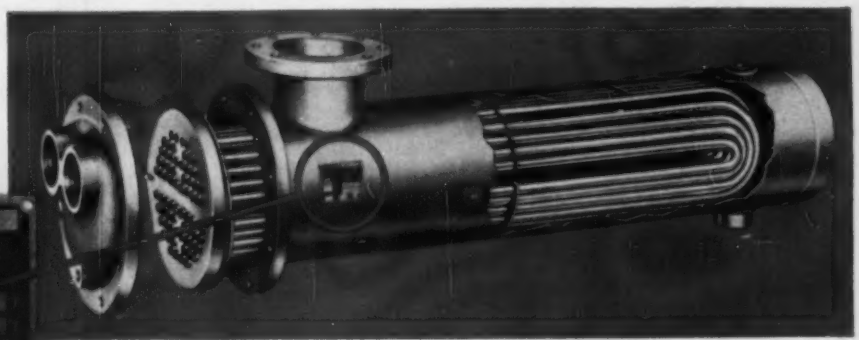
Heat exchangers stocked at B&G plant for serving rush orders

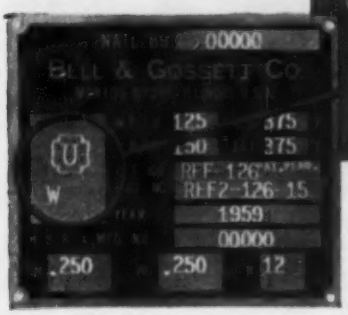
NEED A HEAT EXCHANGER IN A HURRY?

All facilities for heat exchanger manufacture are available under one roof at the B&G plant, where assembly line procedures permit building an inventory of stock parts and complete units. B&G Heat Exchangers are not only engineered to top efficiency but are constructed to the highest standards of quality and safety as required by the A.S.M.E. Unfired Pressure Vessel Code. Form U-1 Manufacturers' Data Report for Unfired Pressure Vessels is furnished with each unit as required by the provisions of the A.S.M.E. Code.

B&G Heat Exchangers are made in both U-bend and straight tube, floating tube sheet models. A comprehensive stock of U-bend exchangers is available for fast shipment. Refrigeration condensers, evaporators, liquid receivers and suction line heat exchangers are also maintained in factory stock.

Send for brochure "The A.S.M.E. Story"





All B&G Heat Exchangers are stamped with A.S.M.E. "U" Symbol

BELL & GOSSETT
COMPANY

Dept. GH-36, Morton Grove, Illinois

Canadian Licensee: S. A. Armstrong, Ltd., 1400 O'Connor Drive, Toronto 16, Ontario

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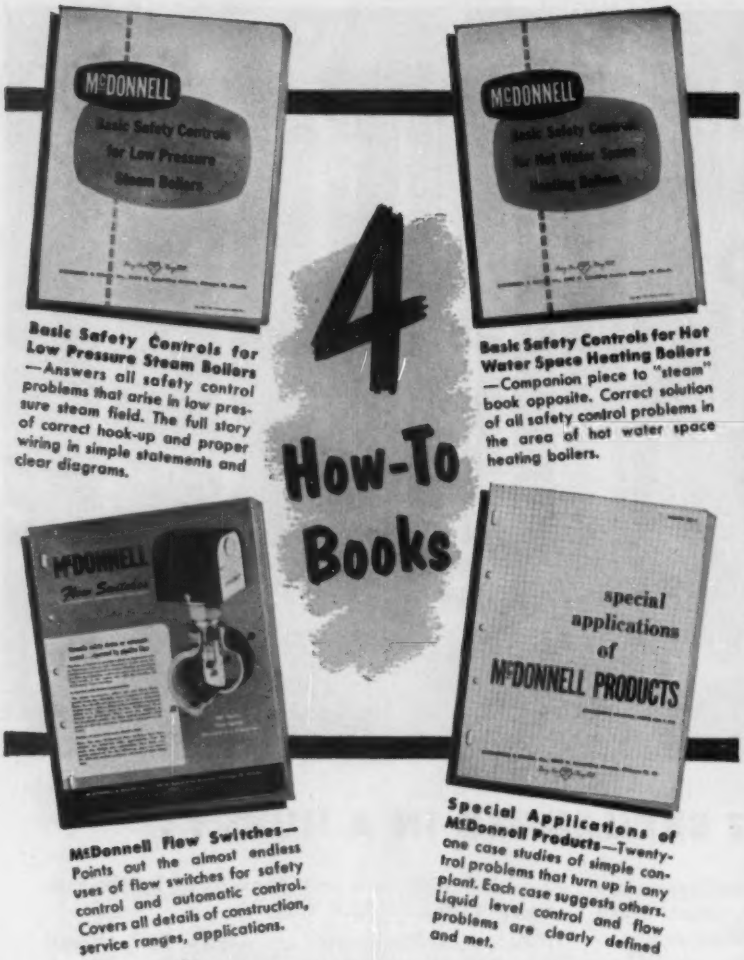

Basic Safety Controls for Low Pressure Steam Boilers—Answers all safety control problems that arise in low pressure steam field. The full story of correct hook-up and proper wiring in simple statements and clear diagrams.

Basic Safety Controls for Hot Water Space Heating Boilers—Companion piece to "steam" book opposite. Correct solution of all safety control problems in the area of hot water space heating boilers.

McDonnell Flow Switches—Points out the almost endless uses of flow switches for safety control and automatic control. Covers all details of construction, service ranges, applications.

Special Applications of McDonnell Products—Twenty-one case studies of simple control problems that turn up in any plant. Each case suggests others. Liquid level control and flow problems are clearly defined and met.

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Mail to: McDonnell & Miller, Inc., 3506 N. Spaulding Ave., Chicago 18, Ill.

Equipment news

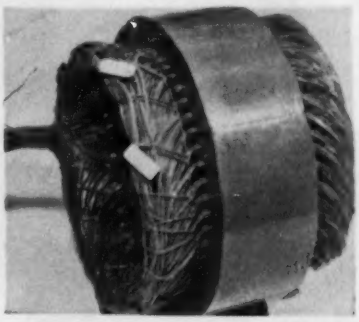
Begins on page 134

Battery-operated vacuum gages

64 • Transistorized gages range from 0 to 1000 microns, 0 to 20 millimeters Hg. Portable or panel-mounted models have high accuracy, rapid response, says maker. They should give continuous, practically instantaneous measurement of gas pressure under vacuum.

Units have matched interchangeable-gage tubes, sealed meter and spring-loaded on-off switch — switch should prevent battery drain when instrument is not in use.—Hastings-Raydist, Inc

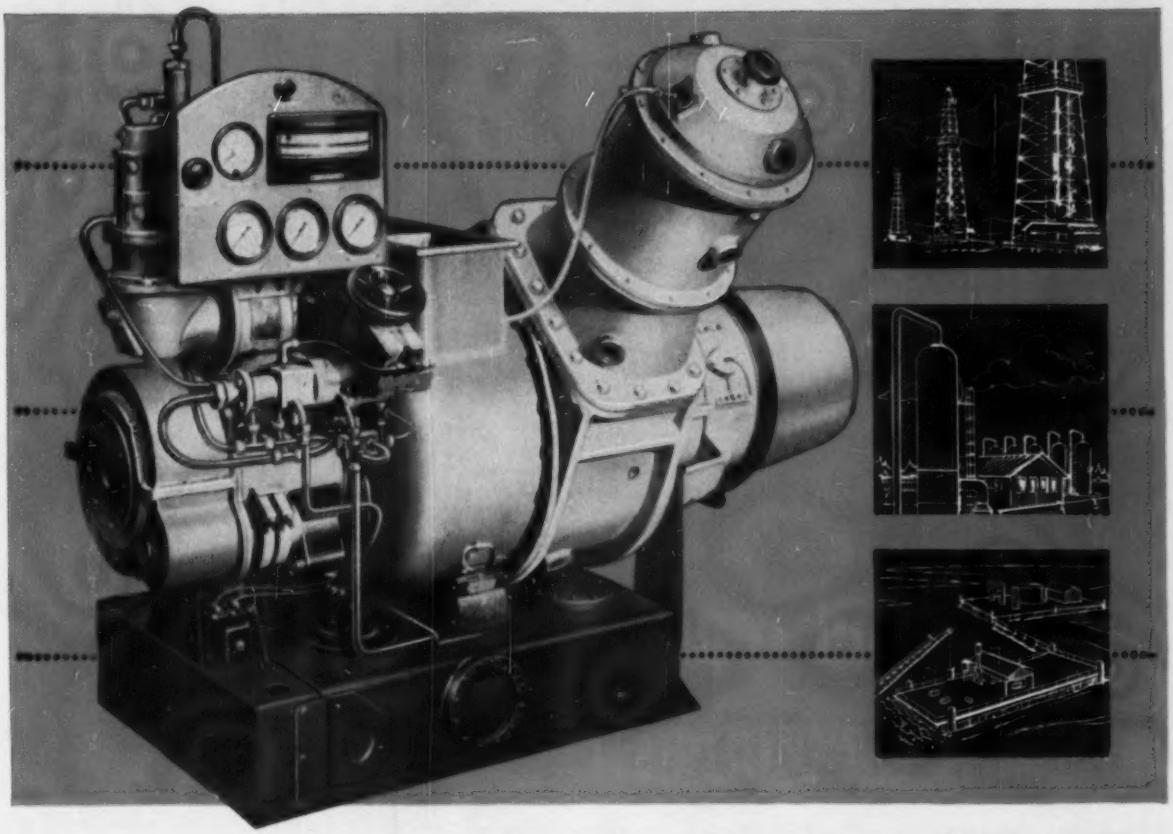
Just circle key numbers on the Reader Service card, page 119, to get complete product story



Ac motor boasts built-in overload protection

87 • Motors with up to 125-hp rating provide simple, positive and fast-acting motor-overload protection,

NEW Thompson-Ruston Model "TE" 430 hp Industrial Gas Turbine



This engine will change forever your concept of gas turbine power. That's because it's engineered from the ground up for heavy-duty service . . . designed to bring you all the benefits of gas turbine operation in a package rugged enough to meet the demands of industrial applications.

Compared to aircraft-type gas turbines you've seen before, the Model "TE" offers these important advantages:

LOWEST COST PER HORSEPOWER—Lowest first cost, lowest maintenance costs.

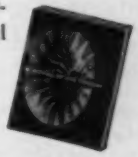
LONGEST LIFE—The only turbine in its horsepower range designed and built for 50,000 hours service life.

SIMPLE DESIGN—Open-cycle type with single-stage centrifugal compressor and single-shaft rotor.

RUGGED CONSTRUCTION—Engineered with low component stresses for heavy-duty service.

EASIEST TO MAINTAIN—Built to deliver a minimum of 5,000 hours between overhauls, with all components easily accessible for routine maintenance.

Complete specifications and performance data on this rugged new industrial gas turbine are yours for the asking. Write on your company letterhead for the Thompson-Ruston Model "TE" catalog.



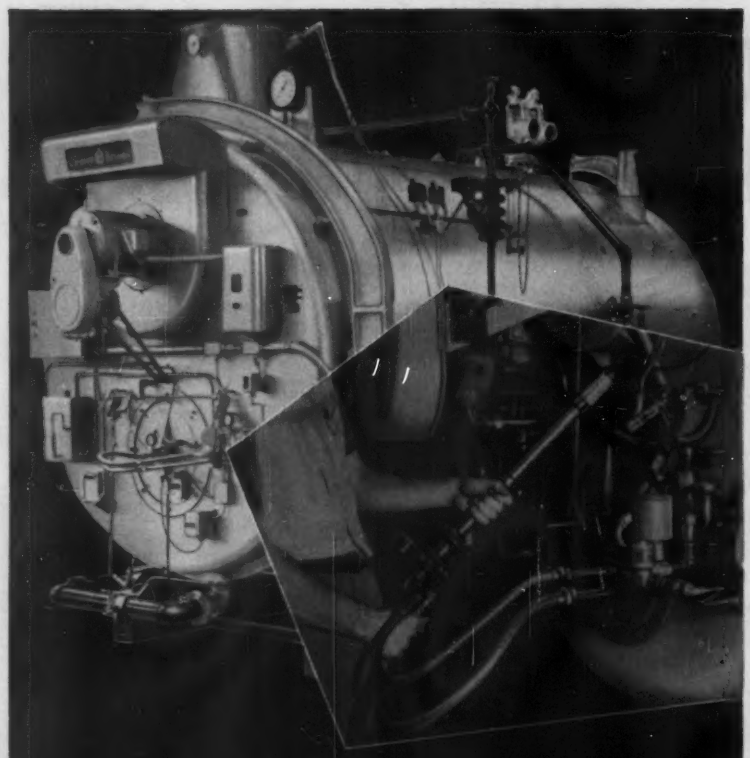
TRW

TAPCO GROUP

Thompson Ramo Wooldridge Inc.

Dept. P-860, Cleveland 17, Ohio

For more facts circle 282 on Reader Service card, p. 119



THIS BURNER NOZZLE CAN BE

pulled and replaced in 40 seconds!

On both oil-fired and gas-fired CB packaged boilers, an integral burner puts you money ahead with clean, economical combustion

The photo above shows how easy it is to withdraw the retractable nozzle from the boiler without removing bolts or opening the front head. The whole job takes less than a minute. That's just one of the features of the remarkable integral burner in every Cleaver-Brooks packaged boiler.

The Cleaver-Brooks air-atomizing oil burner atomizes and burns fuel oils (even #6) with low pressure air. Nozzle design determines degree of atomization. No further adjustment is necessary to produce high CO_2. Spray pattern of oil forms at a uniform angle — axial with the furnace — eliminating carbon build-up. Controls on the CB boiler regulate oil viscosity and pressure to the oil-metering valve. Air and fuel are mixed to the right proportions for high combustion efficiency. Burner nozzle and piping are purged on each cycle.

A word about gas firing:

The gas burner on gas-fired CB boilers offers the same well-engineered design. Gas burner on even the largest CB boilers requires less than a pound of gas pressure to operate — an advantage when gas supply pressure is low. You can also select combination burners—quick change-over from oil to gas or reverse.

Write for more information today. Packaged fire tube boilers — sizes through 600 hp for steam or hot water. In larger capacities, Cleaver-Brooks offers Springfield packaged and field-erected water tube boilers. Cleaver-Brooks Company, Dept. J, 301 East Keefe Ave., Milwaukee 12, Wisconsin.

Cleaver Brooks®

ORIGINATOR AND LARGEST PRODUCER OF PACKAGED BOILERS

Equipment news

Begins on page 134

says maker. Miniature heat-sensing switches buried in stator windings shut motor off when internal winding temperature exceeds predetermined amount.

System uses only two additional wires. There are no amplifying relays or complex circuitry.—General Electric Co

Explosionproof floodlight

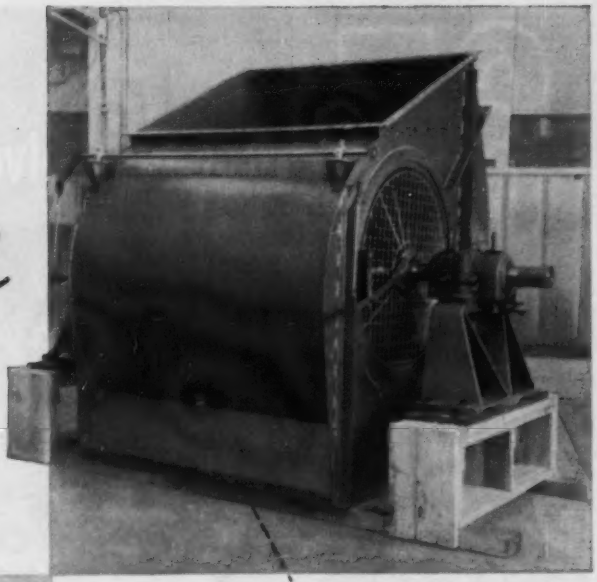
82 • Portable floodlight especially for hazardous locations has cast corrosion-resistant aluminum-alloy housing, tempered-glass lens held by a clamping ring. It's suitable for indoor and outdoor applications, and optional flat base and explosionproof junction box permit permanent installation. Unit is convenient for maintenance and repair operations —Crouse-Hinds Company

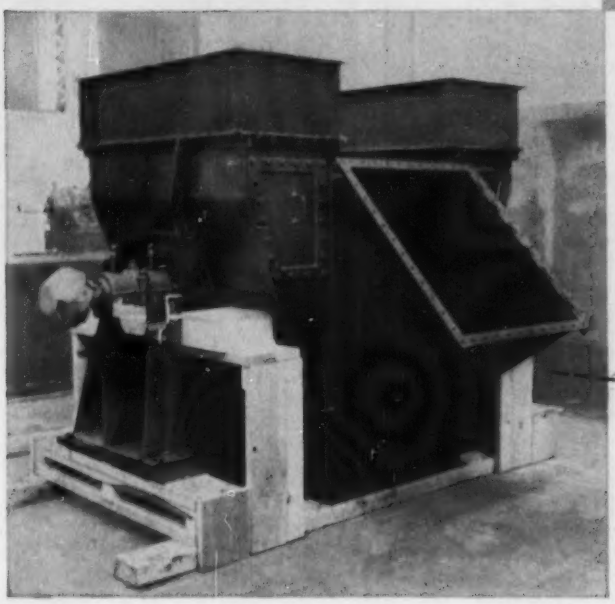
Just circle key numbers on the Reader Service card, page 119, to get complete product story

Pillow blocks permit easy liner replacement

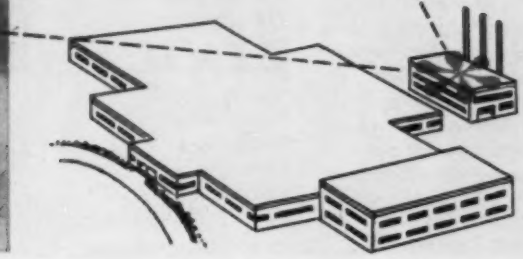
79 • You can replace bronze precision liners quickly and easily without removing bottom half of housing from its support, says maker. Simply remove block's cap, lift shaft just

Headed for another tough job





...this mechanical draft "team" of top performers from CLARAGE



FOR FORCED DRAFT... FOR INDUCED DRAFT... AGAIN CLARAGE QUALITY IS THE CHOICE! These Clarage units, pictured on the shipping dock, will soon be in service at one of the nation's leading paper mills.

At the top is the Clarage Type AF Dynafoil forced draft fan with airfoil blades and Vortex Controls at the inlets; below is the Clarage Type DN Dynacurve induced draft fan with 36 forward curved blades. Clarage equipment, such as this combination, has been selected for over 4,500 central stations and industrial power plants. These users know that with anything as vital as uninterrupted operation, it pays big dividends to get the best in equipment—Clarage.

For complete information, request Catalog 905 on the Type DN, Catalog 859 on the Type AF, and Catalog 901 on the Type RT induced draft fan.

Dependable equipment for making air your servant

CLARAGE FAN COMPANY

Kalamazoo, Michigan

SALES ENGINEERING OFFICES IN ALL PRINCIPAL CITIES • IN CANADA: Canada Fans, Ltd., 4285 Richelieu St., Montreal

67 Problems Solved by Van-Cor PVC Pipe & Fabrications

✓ CHECK THIS LIST

PIPE

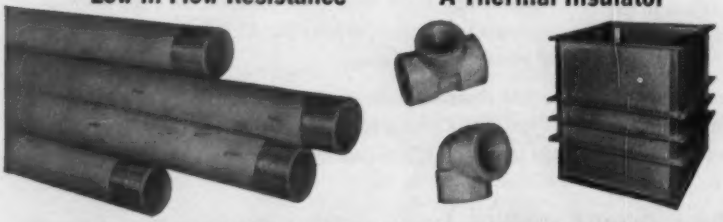
- Piping Sulphuric Acid
- Piping Hydrochloric Acid
- Piping Nitric Acid
- Piping Battery Acid
- Piping Vinegar
- Piping Brine
- Piping Natural Gas
- Piping Ammonium Nitrate
- Piping Gasoline
- Piping Fluoridation materials water system
- Piping Sodium Hypochloride (Bleach)
- Piping Pulp Stock Lines
- Piping Uranium ore slurry
- Piping Sand slurry
- Piping Coal slurry
- Piping Waste Lab Drains
- Piping Cyanide
- Piping Plating Solutions
- Piping Mercury (tube filling)
- Piping Pickles
- Piping Polysulfide
- Piping Wine
- Piping Gin
- Piping Whiskey
- Piping Sea water
- Piping Chicken feed
- Piping Demineralized H_2O
- Piping Warm glue
- Piping Salt water
- Piping Crude oil
- Piping Drinking water
- Piping Irrigation water
- Piping Chilled water
- Piping Sewage
- Electrical Conduit
- Fishing Boat Outriggers
- Stair Handrails
- Vent Stacks
- Stand Pipes
- Downspouts
- Cathodic Protectors
- Electrolytic Interruptors
- Pneumatic Conveying

FABRICATIONS

- Plating fumes
- Hydrofluoric Fumes (Scrubber and duct)
- Meat Cutting Boards
- Spray Booths
- Roll Coverings
- Swimming Pool H_2O Treatment
- Chicken Feed Troughs
- Gutters
- Plating Racks
- Electrolyte Diffusers
- Agitator
- Noise Dampeners
- Sinks
- Laboratory Table Tops
- Photographic Trays
- Etching Trays
- Pump Bodies
- Etching Machinery
- Tumbling Barrel Liners
- Plating Drums
- Loading Chute Liners
- Laboratory Fume Duct
- Laboratory Fume Hood
- Tanks & Tank Liners

VAN-COR SOLVED THESE PROBLEMS BECAUSE IT IS:

Chemical Resistant
Light Weight
High in Tensile Strength
Low in Flow Resistance
Impact Resistant
Dielectric
Easily Installed
A Thermal Insulator



WRITE FOR INFORMATION AND NAME OF NEAREST DISTRIBUTOR

INDUSTRIAL DIVISION OF
COLONIAL PLASTICS MFG. CO.
Subsidiary of THE VAN DORN IRON WORKS CO.
2685 EAST 79TH STREET CLEVELAND 4, OHIO

Equipment news

Begins on page 134

enough to loosen lower half of liner and slip it out. Insert and seat new bronze liner by slight tapping.

Semisteel housings with tongue-and-groove joints or fitted bolts prevent cap's shifting. Brass retainer spool recessed between cap and base of housing prevents liner rotation with shaft. Designed for heavy duty, bronze-lined blocks will withstand elevated temperatures, high shaft speeds, shock and pressure, says manufacturer.—Dodge Mfg Corporation

Air mover

40 • Device exhausts welding fumes and smoke from closed work areas. Tubing connects special intake nozzle to jet-pump casting. From this point, smoke is exhausted through another connecting section of tubing to any discharge point.

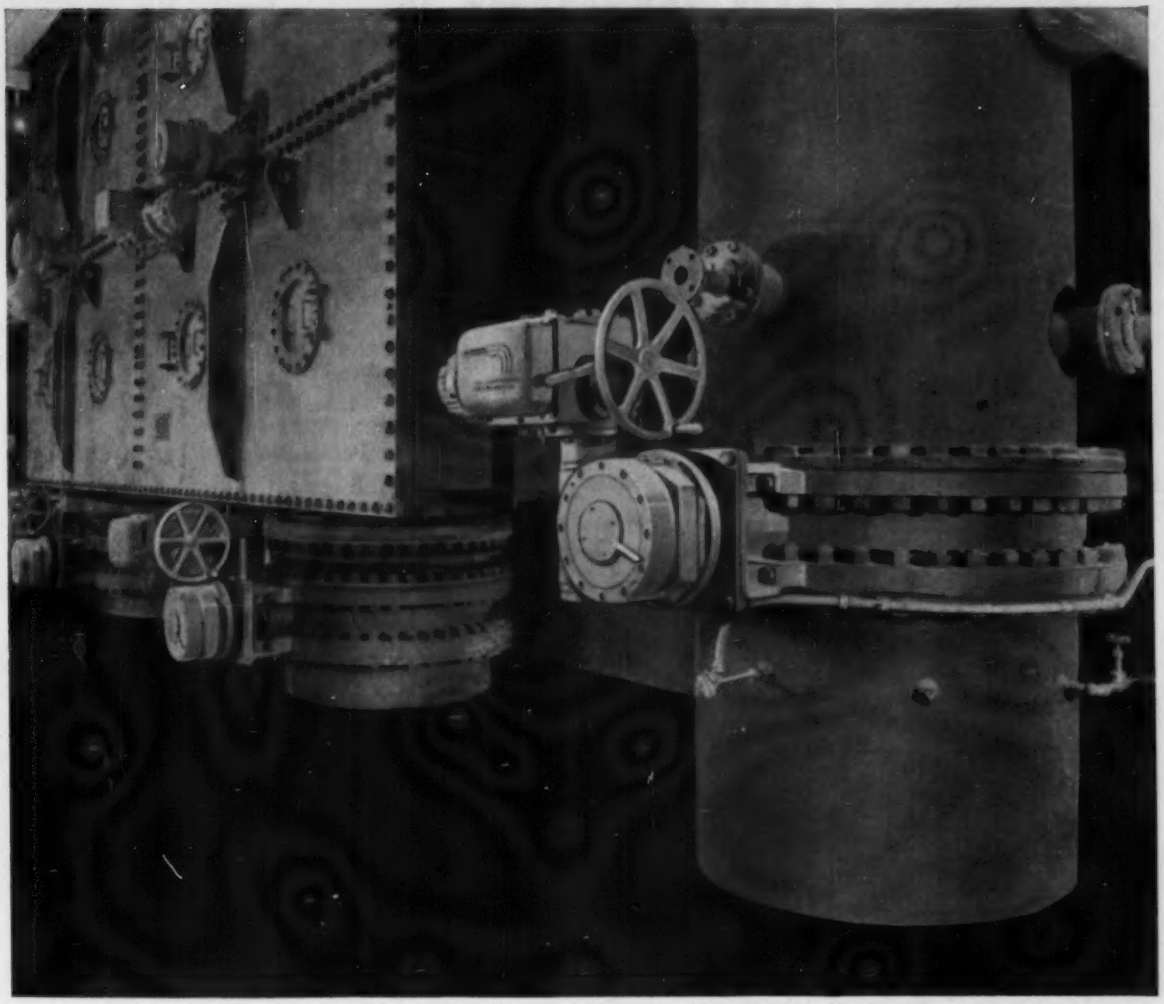
No heavy or space-consuming electric motors are required—unit is powered entirely by compressed air. Operation requires connecting device to air line positioned to carry smoke and fumes away from work area.—Arcair Co

Just circle key numbers on the Reader Service card, page 119, to get complete product story

Flow-actuated electrical switch starts, stops valves

37 • Switch can start and stop pumps, valves, alarms, signals or controls. It meets safety requirements for protecting expensive equipment against hazards of undesirable increase, decrease, reversing or loss of flow. Made of brass, bronze, steel and stainless steel, switch fits lines from ¼ to 60 in. Construction is leakproof

ALLIS-CHALMERS



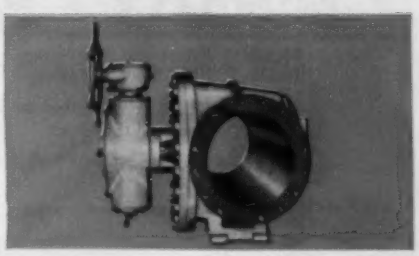
A-C rubber-seated butterfly valves now in service at Potomac Electric Power Company, Dickerson, Md.

65 A-C rubber-seated butterfly valves

selected by Pepco for Dickerson Station

Full body protection is a guaranteed advantage with Allis-Chalmers rubber-seated butterfly valves. Potomac Electric Power Company depends on them, utilizing sizes from 6 to 72 inches in its new generating station at Dickerson. Forty-one butterfly valves are wafer type currently finding application where nonrotary valves once were the *rule.*

Allis-Chalmers rubber-seated butterfly valves are designed to reduce maintenance, eliminate tuberculation and oxidation . . . provide 100% effective shutoff. Operation is always *extra-smooth and easy. For details on our range of butterfly, ball and cone valves for power-plant applications, contact your A-C representative or write* **Allis-Chalmers,** *Hydraulic Division, York, Pa.*



ROTOVALVE units assure the most positive closing offered by any valve. Yet there's no more resistance to flow when full open than with a straight pipe of equal inside diameter. Closing time precisely controllable.

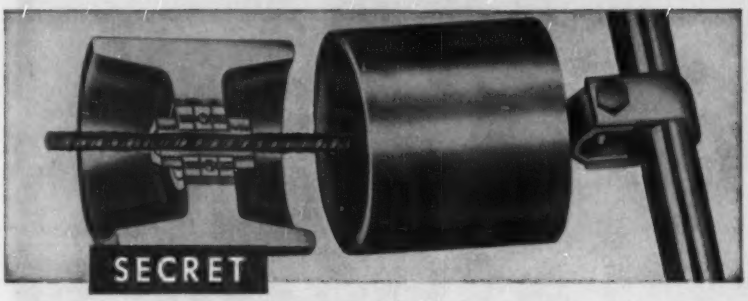
A-1330

Rotovalve is an Allis-Chalmers trademark.

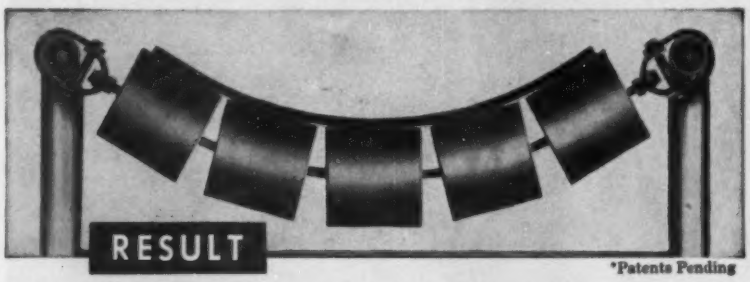
For more facts circle 286 on Reader Service card, p. 119

NEW (EXCLUSIVE WITH McNALLY PITTSBURG) CONVEYOR DESIGN

... slashes maintenance cost!
... extends belt life!



... of the amazingly improved efficiency of this modern belt conveyor is shown here. This new McNally Pittsburg Cradle Idler* consists of 5" rubber rollers assembled on precision ground ball bearings, prelubricated and lifetime sealed. Being a *true catenary* suspension with rollers mounted on flexible, *non-rotating* stainless steel wire rope, this design eliminates "loping" and dangerous harmonics.



*Patents Pending

... is greater capacity and faster belt operation with minimum spillage. Since the belt lies in true arc with no creases or bends to cause wear, *belt life is substantially increased.* Because this McNally Pittsburg conveyor design is so simple, costs are lower, and erection time is reduced.

WRITE TODAY | for details on the new conveyor which costs less to install . . . *saves money every day it is in use.*

McNALLY · PITTSBURG

McNally Pittsburg Mfg. Corp.
Dept. PO, Pittsburg, Kansas

☐ Please send information on the new McNally Pittsburg belt conveyor.

☐ Have Sales Engineer call for further consultation.

Name_____ Title_____

Company_____

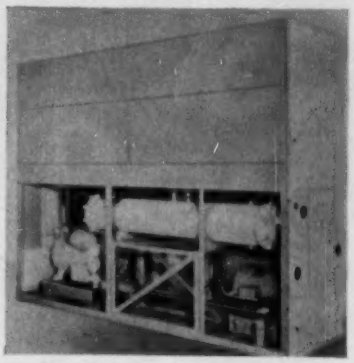
Address_____

City_____ State_____

Equipment news

Begins on page 134

—no packing glands or stuffing boxes.—Power Equipment and Engineering Company, Inc

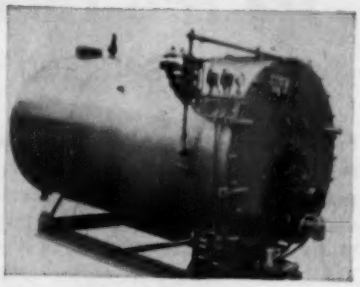


Packaged multizone air conditioners

22 • Rugged equipment comes in 25-, 30- and 40-ton sizes, has nominal air-holding capacities of 10,200, 12,600 and 17,000 cfm. Single zone or multizone units feature quiet operation.

Cabinet has a structural-steel frame with zinc-coated and phosphatized-steel panels. Fans are arranged for blow-through operation. On the control panel only on-off switch is externally accessible. Indicator lights show operation and quickly locate trouble spots in case of malfunction. Equipment is available for 220 to 440 v.—American-Standard Industrial Div

Just circle key numbers on the Reader Service card, page 119, to get complete product story

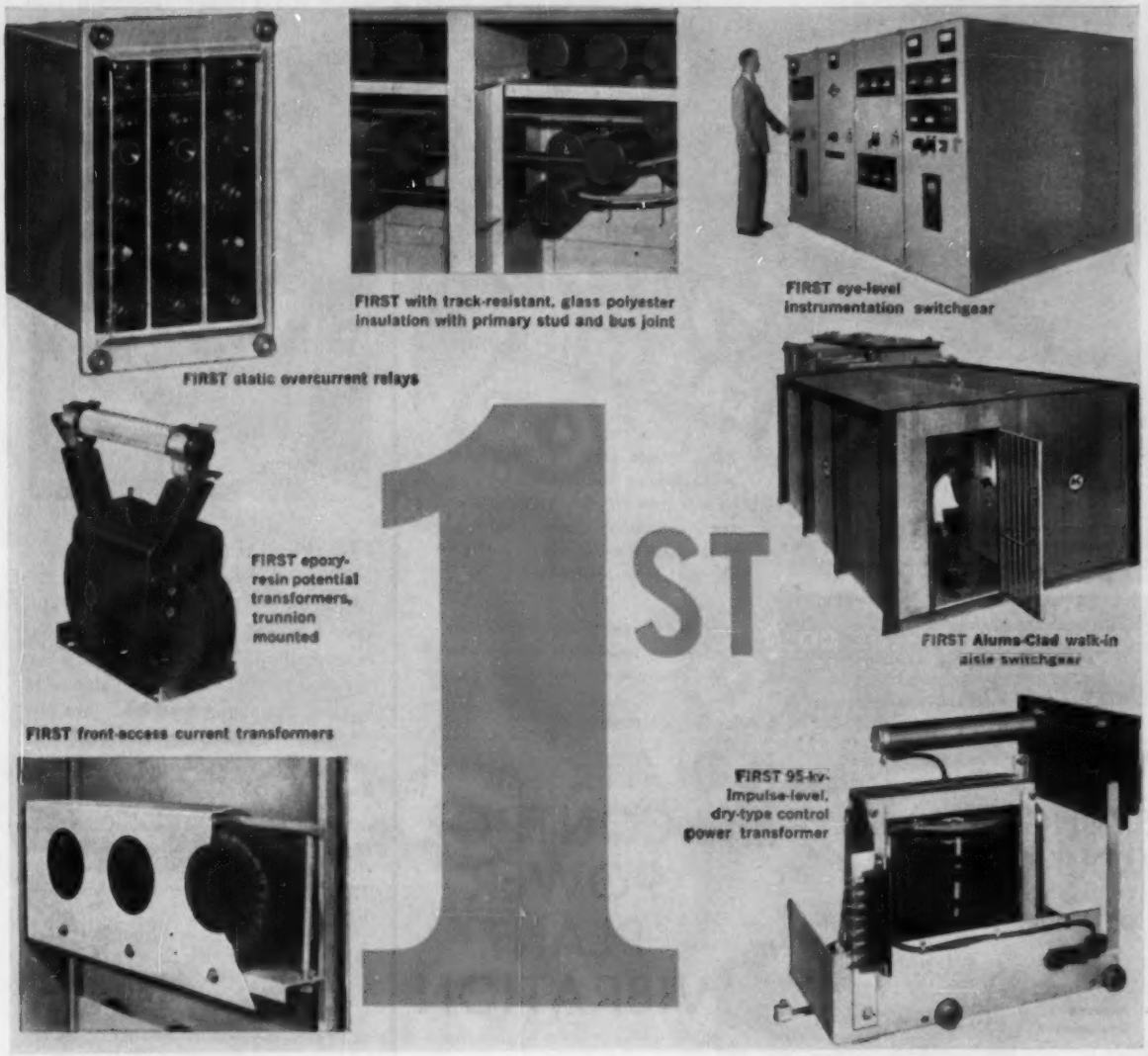


Automatic packaged boilers

39 • Boiler series includes models for light-oil, natural-gas or combination gas-light-oil operation.

continued

ALLIS-CHALMERS


FIRST static overcurrent relays
FIRST with track-resistant, glass polyester insulation with primary stud and bus joint
FIRST eye-level instrumentation switchgear
FIRST epoxy-resin potential transformers, trunnion mounted
1ST
FIRST Alume-Clad walk-in aisle switchgear
FIRST front-access current transformers
FIRST 95-kv-Impulse-level, dry-type control power transformer

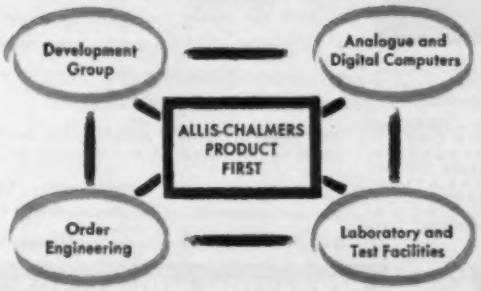
...from the company that put

Progress in Switchgear

For 113 years Allis-Chalmers has built a reputation for the finest products in the industry. A-C is continuously developing new ideas, new techniques and new products to serve you better. This same leadership spirit has quickened the pace of switchgear progress. It's responsible for the firsts illustrated above. These testify to one company's research and engineering *action*.

There are still better things to come in switchgear. You'll get them all when you specify better switchgear ... designed, built and *guaranteed* by **Allis-Chalmers,** Power Equipment Division, Milwaukee 1, Wisconsin. A-1357

Alume-Clad is an Allis-Chalmers trademark.



Intradepartment teamwork bridges all gaps ... smoothly integrates information, machines and men ... speeding overall progress in Allis-Chalmers switchgear.

One of the two 380-ton MURCO Gate Hoists furnished to the Power Authority of the State of New York.

Each hoist operates a gate 46' wide by 67' high at one foot per minute. These gates divert the water from the Niagara River above the Falls into covered conduits five miles long. The two conduits bring the water to the Niagara Generating Plant on the United States side of the Falls.

The engineers on this project are Uhl, Hall & Rich of Boston, Massachusetts.

MURCO Gate Hoists are designed and made for any size power dam . . . capacities from less than 1 ton to over 375 tons . . . from the smallest hand operated to the largest motor operated gate hoist, all made to specifications.

D. J. MURRAY MANUFACTURING CO.
Manufacturers Since 1883
WAUSAU, WISCONSIN

Write for complete information . . . Engineering Department recommendations . . . when you are planning power dam projects.

For more facts circle 289 on Reader Service card, p. 119

VM SPRING-FLEX MOUNTINGS

ISOLATE and CONTROL POWER PLANT VIBRATION

Pat. No. 2,823,882

- Improve Operation
- Cut Maintenance Costs

in Industry
Missile Bases
Air Conditioning & Refrigeration

Diesel-Generator on VM Type SF Mountings:

NO EXPENSIVE CONCRETE FOUNDATION NEEDED — NO VIBRATION TRANSMISSION — LONGER EQUIPMENT LIFE

Simple, compact, easy-to-install—VM Spring-flex Mountings
- Soak up machine-damaging vibrations
- Eliminate need for costly concrete foundations
- S.t.r.e.t.c.h machine life
- Reduce noise transmission

Wide range of standard models insures maximum attenuation of undesirable lateral and vertical shock and vibration disturbances.

Write, wire, phone TODAY for complete VM Catalog P-860

If it's a noise or vibration problem, get the right answer—quick—from

VIBRATION MOUNTINGS, INC.

98-37 50th Avenue, Corona 68, N. Y. • Hickory 6-2370

Equipment news

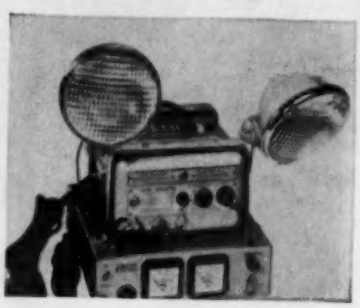
Begins on page 134

Units have compact 3-pass design. Single motor drives both fan and oil pump. Forced draft eliminates necessity for tall stacks or other auxiliary draft equipment.—Western Boiler Company

Electrical power load bank

38 • Power load bank uses thin-plate woven-wire-mesh conductor. Exceptionally lightweight (less than five lb), it is easily carried from station to station. Simulated load bank has low retained-heat capacity and low surface temperatures. Available up to 15 kw, 110 or 28 v.—Electrofilm, Inc

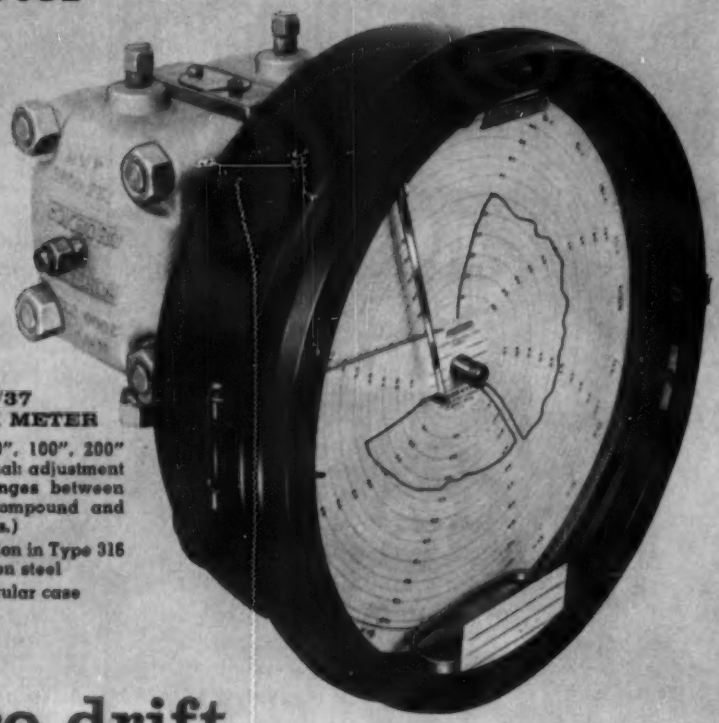
Just circle key numbers on the Reader Service card, page 119, to get complete product story



Automatic emergency-lighting and power units

42 • Automatic units are designed to permit immediate continued operation of critical lighting systems in case of power-line failure. Units will provide 115-v ac if power fails for any reason. Equipment features instant starting, frequency stability and built-in power-factor correction. — American Television & Radio Co

unmatched stability in a "dry" flow meter



FOXBORO T/37 DIAPHRAGM METER

- Ranges: 20", 50", 100", 200" standard (Optional: adjustment for full scale ranges between 25" and 200"; compound and expanded ranges.)
- Forged construction in Type 316 stainless or carbon steel
- Round or rectangular case

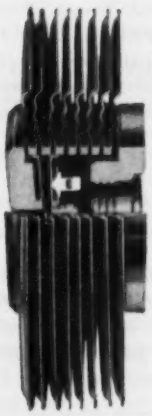
No zero drift... Complete overrange protection

Mercuryless flow measurement over a wide range of differential pressures — at static pressures up to 2000 psi (2500 psi optional). That's the story behind Foxboro's unique Type 37 Diaphragm Flow Meter.

No matter how often you check its accuracy you'll find no need to reset zero or span. Four vital construction features assure this remarkable stability:

1. Unique nesting diaphragm element of Type 316 S.S. which responds to changes in pressure with unmatched sensitivity yet cannot be damaged by overrange...
2. Packless drive bar which transmits precise linear motion to pen arm without "hang-up"...
3. Bi-metallic temperature compensator which precisely counteracts changing volume of the filling fluid...
4. Heavy Ni-span C alloy range springs which are unaffected by changes in line temperature...

Get full details on this high utility, completely dependable diaphragm flow meter. Write for Bulletin 7-15A. **The Foxboro Company, 688 Neponset Ave., Foxboro, Mass.**

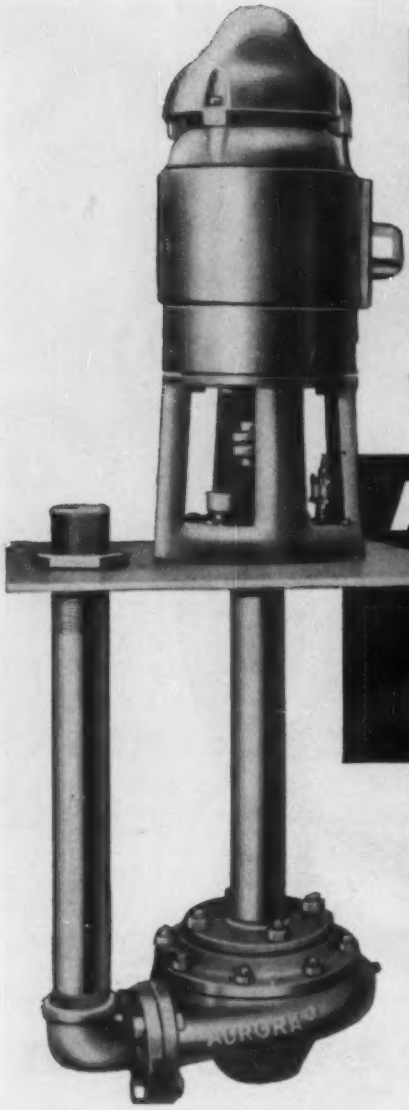


Type 316 S.S. diaphragm elements, in both high and low pressure chambers, provide greatest linearity and freedom from hysteresis. Nesting design, and integral spacer rings provide positive overrange protection. Bi-metallic temperature compensator (E) adjusts the capacity of the diaphragm assembly to counteract changing volume of the filling fluid.

FOXBORO
REG. U.S. PAT. OFF.

first in flow metering

For more facts circle 291 on Reader Service card, p. 119



Profit by Controlled Performance with...

AURORA® SUMP PUMPS

- PROVEN DEPENDABILITY
- APPLICATION ANALYSIS
- CALCULATED CAPACITIES
- SELECTED COMPONENTS
- HIGHEST QUALITY CONTROL
- RUGGED CONSTRUCTION
- MINIMIZED WEAR
- STANDARDIZED SERVICE FLEXIBILITY
- HEADS TO 170 FT.
- CAPACITIES TO 1500 G.P.M.

Ruggedness of construction and simplicity of design of AURORA pumps combine to provide longer life, highest efficiency, and minimized down time. This means more for "your pump operating dollar." Select from the "1001" types, sizes, and capacities of AURORA pumps to obtain *the one* specifically designed to fit your needs. AURORA sump type pumps are most frequently used for industrial wastes, industrial processing, boiler pit service, chemical transfer, corrosive liquid handling, pumping volatile liquids, washing services, and general purpose drainage.

WRITE TODAY FOR YOUR COPY OF BULLETIN 104

AURORA Always PUMPS

AURORA PUMP DIVISION
THE NEW YORK AIR BRAKE COMPANY
1000 LOUCKS STREET • AURORA • ILLINOIS

LOCAL DISTRIBUTOR IS LISTED IN THE YELLOW PAGES OF YOUR PHONE BOOK

Equipment news

Begins on page 134

Portable pH meter gives easy, rapid reading

90 • *Model 700* weighs five lb, features a big scale allowing easy reading of values within .02 pH. Unit operates on 115-v-ac outlet.

Meter has single operating control, high-output electronically modulated amplifier. Compact housing lets you carry instrument in one hand to use wherever needed.—Analytical Measurements, Inc

Just circle key numbers on the Reader Service card, page 119, to get complete product story

Automatic controls start, load, shut down combustion engines

20 • Pneumatically actuated control system was designed for gas-compressing applications. It incorporates safety functions to signal or shut down engines in case of malfunction of many measurable variables.

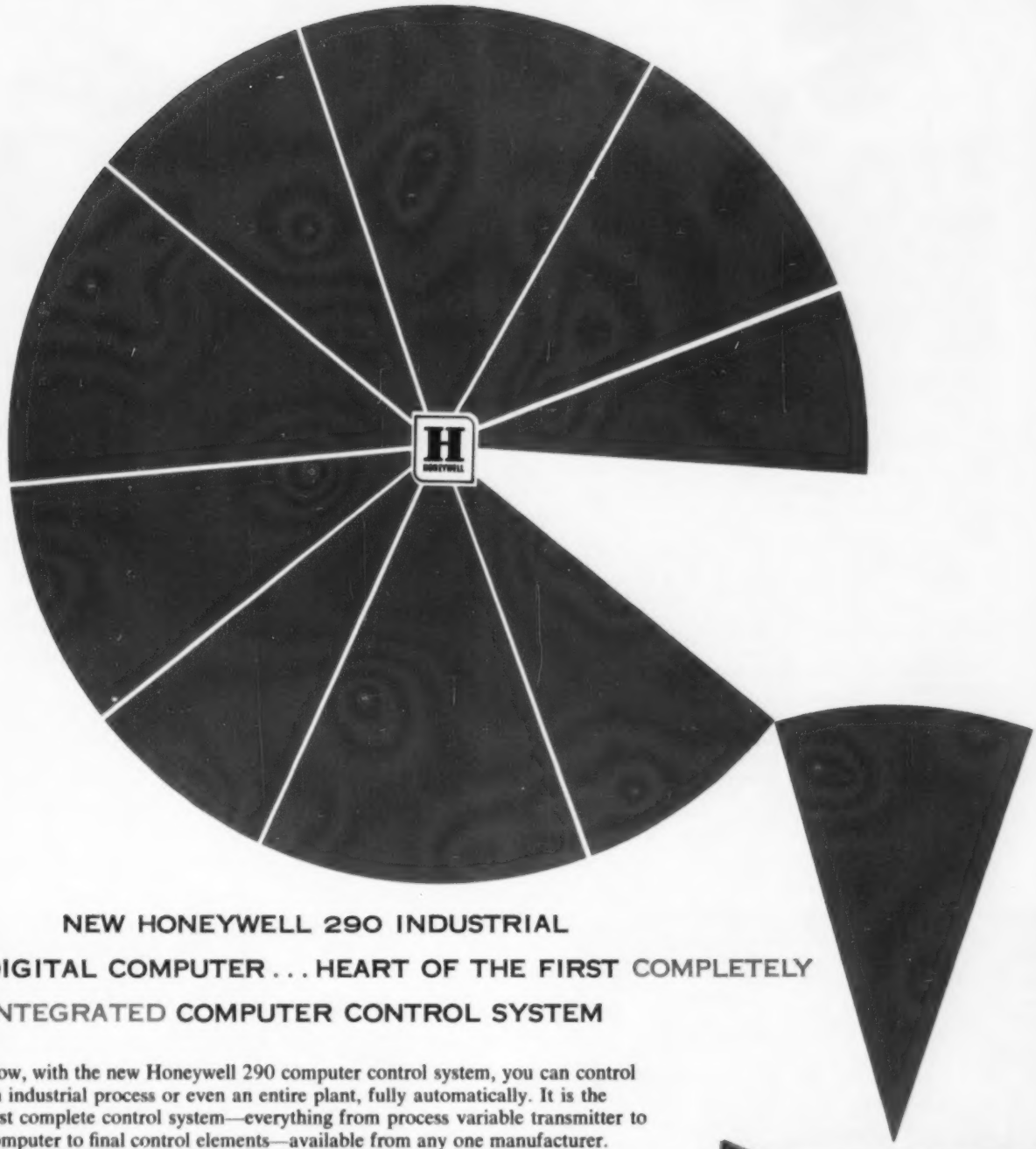
System is explosionproof and has pneumatic circuitry with simplified components for maintenance ease. "Bull's-eye" annunciators flush-mounted on control panel do not have to be reset. Each system is engineered to meet specifications.—Robertshaw-Fulton Controls Co

Correction

Last month's article on Chemalyzer monitoring hardness through photoelectric comparison contained an error. Motor proportions 0.7-cc reagent feed—not 0 to 7 cc.

For more facts circle 292 on Reader Service card, p. 119

circle 293 on Reader Service card, p. 119 ➤

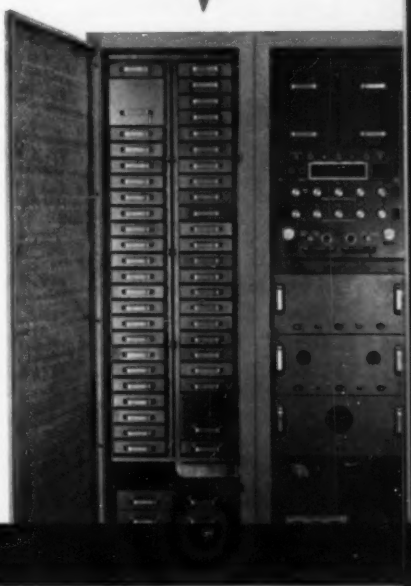


NEW HONEYWELL 290 INDUSTRIAL DIGITAL COMPUTER . . . HEART OF THE FIRST COMPLETELY INTEGRATED COMPUTER CONTROL SYSTEM

Now, with the new Honeywell 290 computer control system, you can control an industrial process or even an entire plant, fully automatically. It is the first complete control system—everything from process variable transmitter to computer to final control elements—available from any one manufacturer. Heart of the system is the new Honeywell 290 industrial digital computer.

The Honeywell 290 is the most powerful computer in its class, despite its small size, low cost and low power consumption. It performs, for example, 8,000 additions, 1,250 multiplications or 400 square root extractions per second. Unique, powerful macro-instructions help make the 290 easy to program, reduce working memory requirements and increase operating speeds. These special instructions augment the basic instructions, and eliminate many special subroutines.

The combination of high-speed operation and the reliability of conservative solid-state circuitry brings optimum control of many types of industrial processes. In addition, the Honeywell computer control system can compile complex operating guides, correlate data, and reduce huge masses of acquired data into immediately usable information for monitoring or optimizing process operations.



NEW HONEYWELL 290 INDUSTRIAL DIGITAL COMPUTER . . . HIGH SPEED, PARALLEL OPERATION, EASILY PROGRAMMED

The high computation speed of the Honeywell 290 provides many advantages in on-line monitoring and control of industrial processes:

- Higher sampling rates give closer control because each variable can be checked more frequently.
- More work can be accomplished in a given time.
- Checking and validity routines can be used extensively.
- Tasks other than process control can be accomplished either through time-sharing or through priority instructions in the computer program.

The Honeywell 290 is the first industrial digital computer to use parallel operation within the computer. All digits in a multi-digit number are transferred *simultaneously* from one element to another within the computer . . . in one count of the clock. Therefore a much slower clock rate can be used. Components are operated far below their maximum ratings—greatly increasing overall reliability, while permitting many thousands of program steps to be executed each second.

The computer combines both magnetic core and drum memory. Main memory is the magnetic core type, and it can be supplied with capacities of 1,024, 2,048 or 4,096 words. A magnetic drum memory with a capacity of either 4,096 or 8,192 words is also provided—a total capacity of 12,288 words. This combination gives you the speed and random accessibility of core memory with the program permanence of drum memory.

The Honeywell 290 Computer operates with standard, field-proved Honeywell process instrumentation in a completely integrated system of control. *ElectriK Tel-O-Set* transmitters feed process variable input data to the computer. These solid-state, two-wire transmitters convert temperature, pressure, flow and other measurements into electric signals. Various types of computer peripheral equipment are supplied by Honeywell to add flexibility to the system and make it easily expandable to meet future requirements. This equipment includes analog-to-digital and digital-to-analog converters, high-speed paper tape readers and punches, visual displays and electric typewriters. Honeywell *ElectriK Tel-O-Set* transducers make the computer completely compatible with existing pneumatic process measuring and control instruments.

Get complete details from your nearby Honeywell field engineer. Or write for Catalog C-290. MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

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Honeywell

First in Control

SINCE 1885

DOW | **SARAN LINED PIPE**

After more than 3 billion pounds of acid and alkali solutions
No replacement of corrosion-resistant Saran Lined Pipe

When utility power plant piping must carry six million pounds a day of acid-and-caustic-treated water . . . piping in which a single failure would shut down the entire water-treatment system . . . dependable corrosion resistance becomes a matter of public safety.

Wisconsin Electric Power Company's Commerce Street power plant in Milwaukee furnishes steam for heating a 24 square-block area in downtown Milwaukee. In this plant Saran Lined Pipe is used to carry acid-treated and caustic-treated city water to cation and anion tanks for demineralization prior to use in the plant's high-pressure steam system. Approximately 725,000 gallons a day of the corrosive liquids pass through the system, one section of which is shown above.

Saran Lined Pipe was first installed in this power plant 2½ years ago. Since that time, despite a total volume flow of over *THREE BILLION* pounds, there's never been a replacement of the Saran Lined Pipe. Mr. Fred H. Long, Chief Chemist of Power Plants for the company, stated that an additional advantage of Saran Lined Pipe is ". . . we find that the pipe is relatively easy to cut to proper length. We don't have to order exact pre-cut lengths, then wait for delivery. This also . . . looks like the best type of pipe we've tried for resistance to corrosion and ease of maintenance."

Whenever piping systems *must* resist corrosion and chemical activity, no matter how extreme the conditions, it'll pay to specify dependable Saran Lined Pipe. Saran Lined Pipe, fittings, valves and pumps are available for systems operating from vacuum to 300 psi, from below zero to 200° F. They can be cut, fitted and modified easily in the field without special equipment. For more information, write Saran Lined Pipe Company, 2415 Burdette Avenue, Ferndale, Michigan, Dept. 2288DW8.

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REDISCOV

Coal operators on the C&O have done a revolutionary job of modernizing, in both mines and preparation plants to economically produce high quality coals. These investments prove coal is the fuel of the future.

ER COAL!

COAL IS ECONOMY– proved in countless studies with competitive fuels

As forward-looking fuel users continue to *rediscover coal,* a growing file of case histories proves out the economy, versatility and convenience of coal utilized with modern combustion equipment. Here are a few graphic examples.

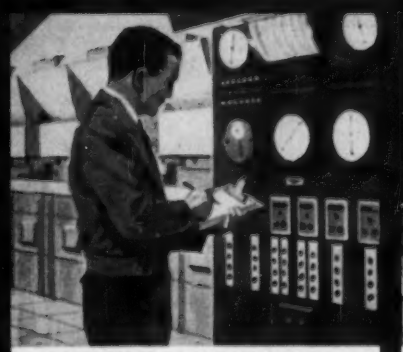
A sprawling university undergoes plant modernization, upgrades heating efficiency 75%. Coal saves a military institute $15,041 yearly over competitive fuel. A machine shop saves $7,787. Coal conversion gives a small tool plant completely automatic operation at lowest cost. An automotive assembly plant reports not only fuel economy but low maintenance, high efficiency and cleanliness as well, from its new coal operated steam plant.

The point is this. Modern advances in coal preparation, handling and combustion equipment have vastly improved the advantages of this biggest bargain in fuel. Today it is mined and transported more economically than ever. And coal is the one fuel certain for *centuries, not decades.*

Chesapeake and Ohio Railway

Terminal Tower • Cleveland 1, Ohio

Outstandability in Transportation

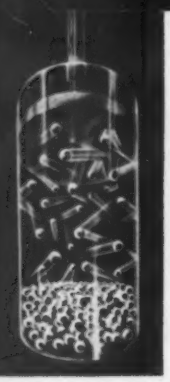


A modern boiler room in pastel colors has a clean, almost clinical appearance. Automatic sealed handling of coal and ash eliminates dust. Advance-design combustion equipment gets top BTU's from low cost coal.

C&O Fuel Service Engineers provide free consultation to C&O patrons on combustion, application, equipment, or plant arrangement problems. Write to R. C. Riedinger, General Coal Traffic Manager, above address.

The 5100-mile Chessie Route directly serves over 300 mines in America's richest bituminous coal reservoir with the finest fleet of 68,000 coal cars. Specify C&O routing for dependable, efficient delivery.

CHESSIE SERVES THE COAL BIN OF THE WORLD

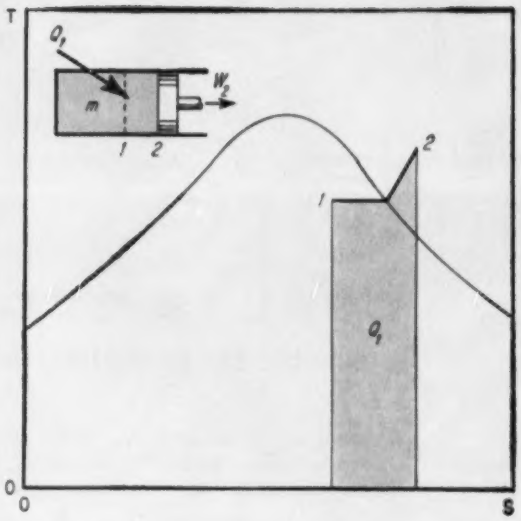


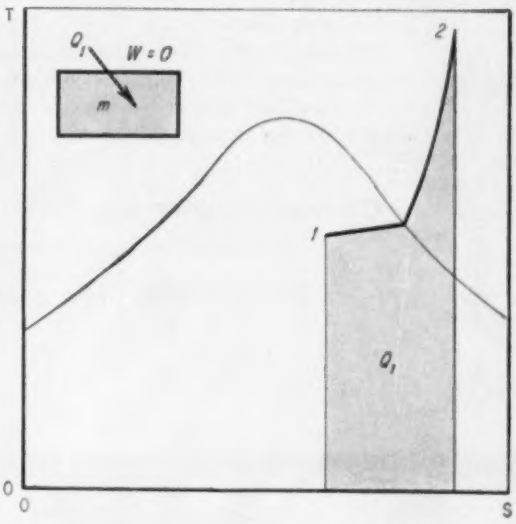
THERMO REFRESHER NO. 41

We only get to "know" a theory or equation by actually applying it; to quote an old saw, practice makes perfect. Here we do a dual job of reviewing process theory and learning . . .

How to use the Steam Tables

By B G A SKROTZKI, Associate Editor





To get ready for steam-power, vapor-refrigeration and air-cooling cycles we must master vapor-process calculations. Last month we studied the basics of steam processes. Now let's practice applying these and learn how to use the Steam Tables.

Four processes. We'll figure four steam processes: constant pressure ($P = C$), constant volume ($V = C$), constant temperature ($T = C$) and constant entropy ($S = C$). Get out your copy of Keenan and Keyes' *Thermodynamic Properties of Steam* (John Wiley and Sons) and check through the following examples.

The four T-S charts are all drawn to scale. Remember, temperature is *absolute* temperature, °R, but we only refer to F temperature in the Steam Tables. Zero entropy corresponds to 32-F water at 0.08854 psia.

Constant pressure. For the given example we find equation (1) from Steam Table (ST) 2. The vapor and vaporization factors in (2) to (5) we find all at the given pressure of 400 psia.

The process ends at 400-psia pressure and 600-F temperature. Since sat t for the pressure is 444.59 F, the process ends with superheated steam. So we refer to ST 3 to find (6) and (7). Since the superheat steam table does not have internal energy u (or E as we symbolize it) we must figure it from h, P and V as in (8). (9) comes directly from the tables. (10) and (11) are standard equations for the process. Pressures must be stated in terms of psfa so we multiply psia by 144.

To get the total changes for 3 lb of steam we must multiply by $m = 3$ in (12) to (14). (15) is a convenient check on (10) and only disagrees by 0.2 because of slide-rule reading errors.

Constant-volume process. (1) comes from ST 2 corresponding to 120 psia, as do the factors for (2) to (5). Since $T_2 = 1000$ F is higher than any saturation temperature the steam must be superheated.

We must now find the state at $T_2 = 1000$ F and $V_2 = 2.6150$ cu ft per lb in the tables. Look down the 1000-F columns in the superheat table and find this lies between 325 and 330 psia. (8) and (9) list properties for these two pressures at 1000 F. To find the final pressure we must interpolate between v values as in (10).

Since there is only 0.1-Btu difference between the two pressures we can easily estimate h as in (11). In (12) we interpolate to find final entropy. Since the table doesn't list internal energy we find it from H_2 and P_2V_2 as in (13). Adding heat to a constant-V process affects only the internal energy as figured in (14). Total entropy change must take into account the total steam mass $m = 5$ lb, as in (15). By definition W and ΔV must be zero

Constant-pressure process

Given: $P = C$ expansion of 3 lb of wet saturated steam in a cylinder and piston, initially at 400 psia with 15% moisture, finally at 600 F.

Find: $T_1, H_1, E_1, V_1, S_1, H_2, E_2, V_2, S_2, Q_1, W_2, \Delta E, \Delta V, \Delta S$

Answer:

State 1—$P_1 = 400$ psia, $y = 0.15$

$T_1 = t_{sat} = 444.59$ F (1)

$H_1 = h_g - yh_{fg} = 1204.5 - 0.15 \times 780.5 = 1087.4$ Btu per lb (2)

$E_1 = u_g - yu_{fg} = 1118.5 - 0.15 \times 695.9 = 1014.1$ Btu per lb (3)

$V_1 = v_g - yv_{fg} = 1.1613 - 0.15 \times 1.1420 = 0.990$ cu ft per lb (4)

$S_1 = s_g - ys_{fg} = 1.4844 - 0.15 \times 0.8630 = 1.2945$ Btu per lb, F (5)

State 2—$T_2 = 600$ F

$H_2 = 1306.9$ Btu per lb (6)

$V_2 = 1.4770$ cu ft per lb (7)

$E_2 = h - P_2V_2/J = 1306.9 - 400 \times 144 \times 1.4770/778 = 1197.5$ Btu per lb (8)

$S_2 = 1.5894$ Btu per lb, F (9)

$$W_2 = \frac{P_1}{J}(V_2 - V_1)m = \frac{400 \times 144}{778}(1.4770 - 0.9900)3 = 108.1 \text{ Btu} \quad (10)$$

$Q_1 = (H_2 - H_1)m = (1306.9 - 1087.4)3 = 658.5$ Btu (11)

$\Delta E = (E_2 - E_1)m = (1197.5 - 1014.1)\ 3 = 550.2$ Btu (12)

$\Delta V = (V_2 - V_1)m = (1.4770 - 0.9900)\ 3 = 1.461$ cu ft (13)

$\Delta S = (S_2 - S_1)m = (1.5894 - 1.2945)\ 3 = 0.8847$ Btu per F (14)

Check: $W_2 = E_1 - E_2 + Q_1 = -550.2 + 658.5 = 108.3$ Btu (15)

Constant-volume process

Given: $V = C$ heating process of 5 lb of wet steam initially at 120 psia with 30% moisture ending with temperature of 1000 F.

Find: $T_1, H_1, E_1, V_1, P_2, H_2, E_2, V_2, Q_1, W, \Delta E, \Delta V, \Delta S$

Answer:

State 1—$P_1 = 120$ psia, $y_1 = 0.30$

$T_1 = 341.25$ F (1)

$H_1 = h_g - yh_{fg} = 1190.4 - 0.3 \times 877.9 = 927.0$ Btu per lb (2)

$E_1 = u_g - yu_{fg} = 1107.6 - 0.3 \times 795.6 = 868.9$ Btu per lb (3)

$V_1 = v_g - yv_{fg} = 3.7280 - 0.3 \times 3.7101 = 2.6150$ cu ft per lb (4)

$S_1 = s_g - ys_{fg} = 1.5878 - 0.3 \times 1.0962 = 1.2589$ Btu per lb, F (5)

State 2—$T_2 = 1000$ F

$V_2 = V_1 = 2.6150$ cu ft per lb (6)

Total $V_2 = 2.6150 \times 5 = 13.075$ cu ft (7)

At $p = 325$, $v = 2.636$, $h = 1524.5$, $s = 1.7863$ (8)

At $p = 330$, $v = 2.596$, $h = 1524.4$, $s = 1.7845$ (9)

$$P_2 = 330 - \frac{2.615 - 2.596}{2.636 - 2.596}(330 - 325) = 327.62 \text{ psia} \quad (10)$$

$H_2 = 1524.4$ Btu per lb (11)

$$S_2 = 1.7863 - \frac{327.62 - 325}{330 - 325}(1.7863 - 1.7845) = 1.7854 \text{ Btu per lb, F} \quad (12)$$

$$E_2 = H_2 - \frac{P_2V_2}{J} = 1524.4 - \frac{327.62 \times 144 \times 2.615}{778} = 1365.9 \text{ Btu per lb} \quad (13)$$

$Q_1 = (E_2 - E_1)m = (1365.9 - 868.9)\ 5 = 2485$ Btu (14)

$\Delta S = (S_2 - S_1)m = (1.7854 - 1.2589)5 = 2.6325$ Btu per F (15)

$W_2 = 0 \quad \Delta V = 0 \quad \Delta E = Q_1$ (16)

► continued on next page

as shown in (16). Notice the curvatures of the constant-volume line on the *T-S* chart.

Constant-temperature process. (1) comes from ST 2 corresponding to 1200 psia, as do the factors in (2) to (5). When we look up 300 psia we find saturation temperature of 417.33 F, so we know the steam must be superheated in state 2. In ST 3 we find temperatures listed at 560 and 580 F so we must interpolate between these two states at a pressure of 300 psia, as listed in (7) and (8). (9) finds the H_2, (10) the S_2 and (11) the V_2. In (12) we find E_2 from the enthalpy equation. Q_1 is most easily found from the change in entropy as in (13)—remember to put temperature in °R absolute by adding 460. Work output W_2 is found from the nonflow energy equation as in (16). Changes in S and V are found in (17) and (18).

Constant-entropy process. Here we look at both a nonflow and steady-flow process between the same two end states. (1) to (4) we find in the superheat table corresponding to the pressure and temperature, except that E_1 must be figured from the enthalpy equation. Second state is wet steam since the pressure is so low, so

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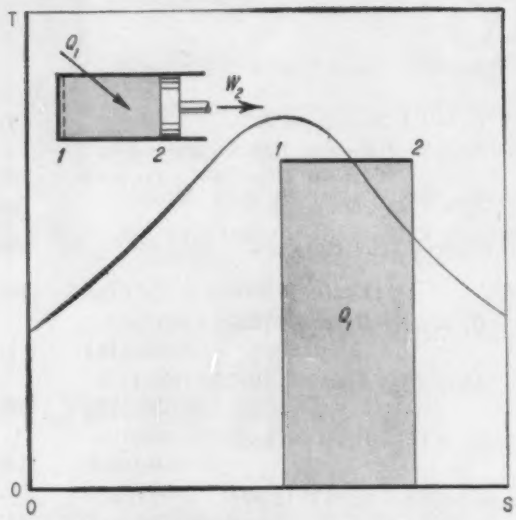


Constant-temperature process

Given: $T = C$ expansion of 6 lb of wet steam initially at 1200 psia and 50% moisture ending at 300 psia.
Find: $T_1, H_1, E_1, V_1, S_1, T_2, H_2, E_2, V_2, S_2, Q_1, W_2, \Delta E, \Delta V, \Delta S$
Answer: *State 1*—$P_1 = 1200$ psia, $y_1 = 0.5$

$T_1 = 567.22$ F (1)

$H_1 = h_g - y_1 h_{fg} = 1183.4 - 0.5 \times 611.7 = 877.5$ Btu per lb (2)

$E_1 = u_g - y_1 u_{fg} = 1103.0 - 0.5 \times 536.3 = 834.8$ Btu per lb (3)

$V_1 = v_g - y_1 v_{fg} = 0.3619 - 0.5 \times 0.3396 = 0.1921$ cu ft per lb (4)

$S_1 = s_g - y_1 s_{fg} = 1.3667 - 0.5 \times 0.5956 = 1.0689$ Btu per lb, F (5)

State 2—$P_2 = 300$ psia; $T_2 = T_1 = 567.22$ F (6)

At $T = 560$, $v = 1.9128$, $h = 1292.5$, $s = 1.6054$ (7)

At $T = 580$, $v = 1.9594$, $h = 1303.7$, $s = 1.6163$ (8)

$$H_2 = 1292.5 + \frac{567.22 - 560}{580 - 560}(1303.7 - 1292.5) = 1296.5 \text{ Btu per lb} \quad (9)$$

$$S_2 = 1.6054 + \frac{567.22 - 560}{580 - 560}(1.6163 - 1.6054) = 1.6093 \text{ Btu per lb, F} \quad (10)$$

$$V_2 = 1.9128 + \frac{567.22 - 560}{580 - 560}(1.9594 - 1.9128) = 1.9296 \text{ cu ft per lb} \quad (11)$$

$$E_2 = H_2 - \frac{P_2 V_2}{J} = 1296.5 - \frac{144 \times 300 \times 1.9296}{778} = 1109.3 \text{ Btu per lb} \quad (12)$$

$Q_1 = T_1(S_2 - S_1)m = (567.22 + 460)(1.6093 - 1.0689)6 = 3330$ Btu (13)

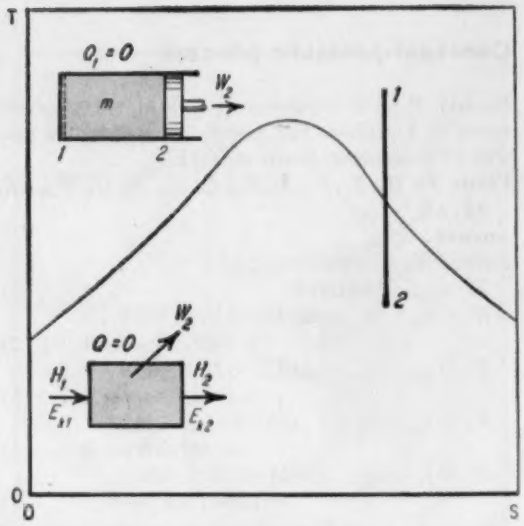
$\Delta E = E_2 - E_1 = 1109.3 - 834.8 = 274.5$ Btu per lb (14)

$\Delta H = H_2 - H_1 = 1296.5 - 877.5 = 419.0$ Btu per lb (15)

$W_2 = (Q_1 - \Delta E)m = (555 - 274.5)6 = 1683$ Btu (16)

$\Delta S = S_2 - S_1 = 1.6093 - 1.0689 = 0.5404$ Btu per lb, F (17)

$\Delta V = V_2 - V_1 = 1.7375$ cu ft per lb (18)



Constant-entropy process

Given: Nonflow and steady-flow $S = C$ expansion of 10-lb steam from initial pressure of 200 psia and temperature of 800 F to final pressure of 2 psia. In steady flow, assume $E_{k1} = E_{k2}$.
Find: $H_1, E_1, V_1, S_1, T_2, y_2, H_2, E_2, V_2, S_2, \Delta E, \Delta H, \Delta S\ \Delta V, Q_1, W_2$
Answer:

State 1—$P_1 = 2000$ psia, $T_1 = 800$ F

$H_1 = 1335.5$ Btu per lb (1)

$V_1 = 0.3074$ cu ft per lb (2)

$$E_1 = h - \frac{P_1 V_1}{J} = 1335.5 - \frac{144 \times 2000 \times 0.3074}{778} = 1221.6 \text{ Btu per lb} \quad (3)$$

$S_1 = 1.4576$ Btu per lb, F (4)

State 2—$P_2 = 2$ psia, $T_2 = 126.08$ F

At 2 *psia*: $s_f = 0.1749$, $s_{fg} = 1.7451$, $s_g = 1.9200$ (5)
$h_f = 93.99$, $h_{fg} = 1022.2$, $h_g = 1116.2$
$u_f = 93.98$, $u_{fg} = 957.9$, $u_g = 1051.9$
$v_f = 0.016$, $v_{fg} = 173.71$, $v_g = 173.73$

$S_2 = S_1 = s_g - y_2 s_{fg}$ (6)

$$y_2 = \frac{s_g - s_1}{s_{fg}} = \frac{1.9200 - 1.4576}{1.7451} = 0.265 \quad (7)$$

$H_2 = h_g - y_2 h_{fg} = 1116.2 - 0.265 \times 1022.2 = 845.3$ Btu per lb (8)

$E_2 = u_g - y_2 u_{fg} = 1051.9 - 0.265 \times 957.9 = 798.0$ Btu per lb (9)

$V_2 = v_g - y_2 v_{fg} = 173.73 - 0.265 \times 173.71 = 127.7$ cu ft per lb (10)

$\Delta E = (E_1 - E_2)m = (1221.6 - 798.0)10 = 4236$ Btu (11)

$\Delta H = (H_1 - H_2)m = (1335.5 - 845.3)10 = 4902$ Btu (12)

$\Delta S = (S_1 - S_2)m = (1.4576 - 1.4576)10 = 0$ Btu per F (13)

$\Delta V = (V_1 - V_2)m = (0.3074 - 127.7)10 = -1274$ cu ft (14)

$Q_1 = 0$ Btu (by definition) (15)

Nonflow $W_2 = \Delta E = 4236$ Btu (16)

Steady-flow $W_2 = \Delta H = 4902$ Btu (17)

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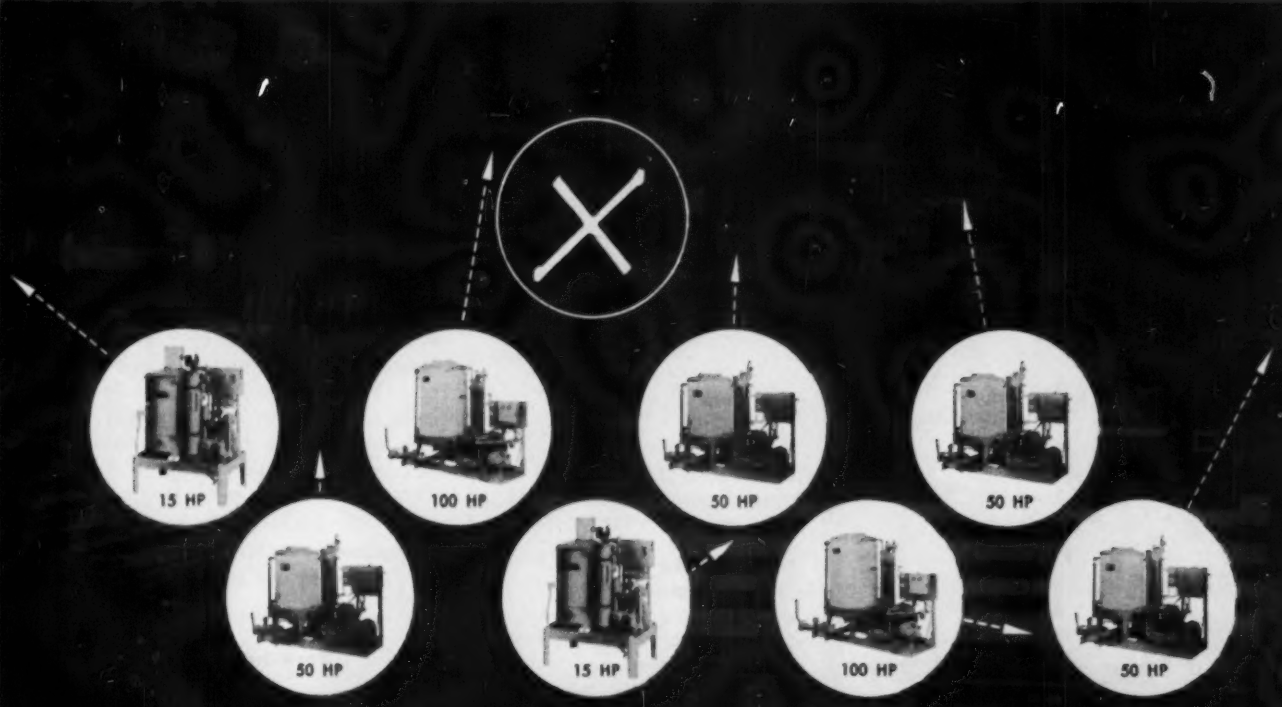

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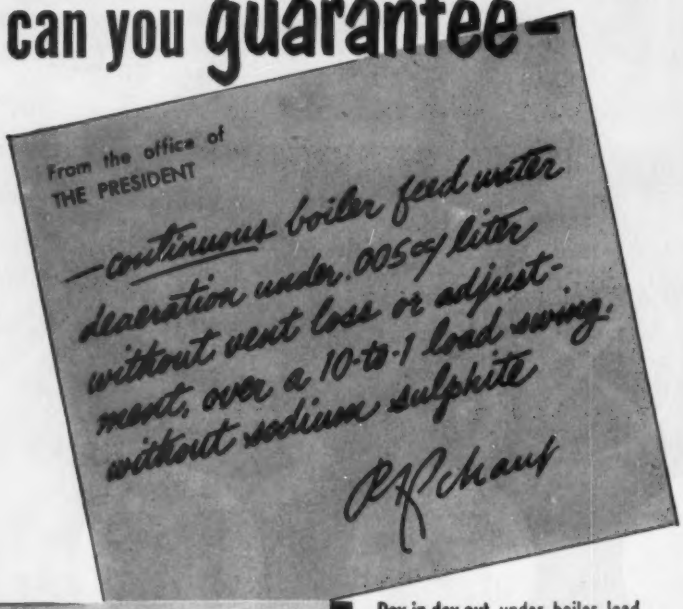
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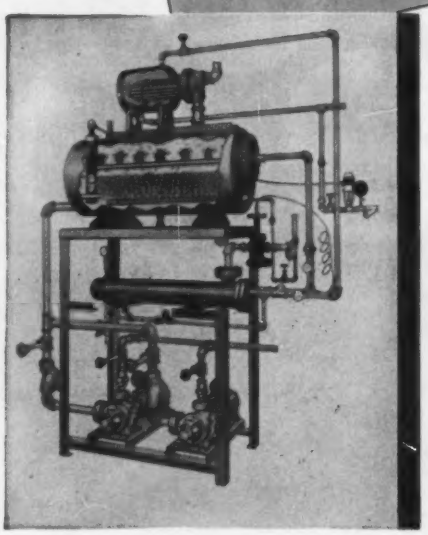

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Please send my personal copy of Bulletin 575

Name_____

Thermo refresher

Begins on page 160

in equation (5) we list the saturated liquid, saturated vapor and vaporization properties corresponding to 2 psia as found in ST 2. In (6) we set up the basic equation for entropy in the wet region and as the known quantity that stays constant in the process.

In (7) we solve for y_2 and substitute factors from the steam table, (5). Knowing y_2 we solve for the other properties in (8) to (10). In (11) to (14) we find total change in properties for the process for 10 lb of steam. By definition there is no transfer of heat in a constant-entropy process as in (15). Nonflow work depends on the change in internal energy, (16). The steady-flow work depends on the change in enthalpy, (17), and is larger than the nonflow work by the amount of change in the flow work.

Next month we will do some more practice with irreversible adiabatics, liquid processes and throttling.

Carrier offers new financing package

Industrial and commercial customers of Carrier Corporation, manufacturer of air conditioning and allied equipment, can now lease and purchase equipment on an installment plan as well as on a conventional cash basis. According to M C Holm, Carrier financial vice-president, this multiple-choice financing package will provide customers with maximum flexibility in determining the plan best suited to their needs.

United States Leasing Corporation, San Francisco, will exclusively handle the leasing of Carrier equipment across the country. Leases will originate and be processed through the 80 branch offices of Carrier's affiliate, Appliance Buyers Credit Corporation, St. Joseph, Mich., which also finances Carrier's installment purchase plans.

Hewitt-Robins Buffalo Rubber Div has new $1,000,000 coal-fired power plant to supply heat and process steam.

Spotlighting 2 NEW VOGT VALVES

★

FORGED STEEL

INSIDE SCREW

Bolted Bonnet

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GATE and GLOBE

VALVES

150-800 Pounds Service

2000 Pounds Cold, W.O.G.

Available from stock in ¼" thru 2" sizes and in both socket weld and screw ends.

CHECK THESE FEATURES

1. Forged steel pressure containing parts designed for light weight and brute strength.
2. Hard faced seats and hardened discs and wedges.
3. Spiral wound stainless steel or Monel gaskets to suit trim.
4. Extra deep stuffing box for long packing life.
5. Dished sure-grip handwheel.

Write for literature Dept. 24A-FP

HENRY VOGT MACHINE CO., LOUISVILLE, KY.

SALES OFFICES

New York, Chicago, Cleveland, Dallas, Camden, N.J., St. Louis, Charleston, W.Va., Cincinnati

Vogt

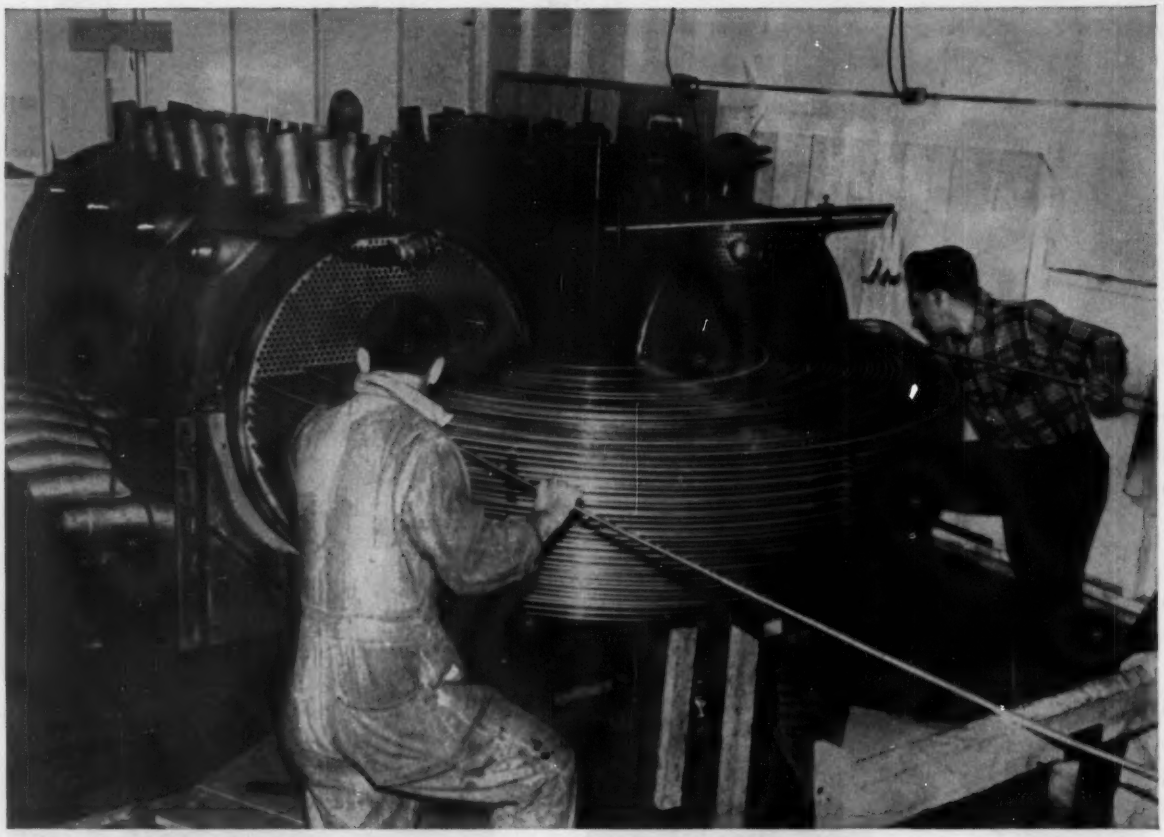
GENERAL G-P PURPOSE

Vogt VALVES & FITTINGS

FORGED STEEL

VALVES

For more facts circle 298 on Reader Service card, p. 119



Builders of Canada's first commercial pressurized-water reactor, NPD-2,

safeguard tubes for "hungry" heavy water against corrosion with Inconel

Many advanced design concepts are incorporated in Canada's NPD-2. One of the most interesting concerns the selection of Inconel* nickel-chromium alloy to prevent corrosion of tubes in the heat exchanger that generates 410 psig steam from ordinary water.

This U-shell-and-tube exchanger receives high-purity pressurized heavy water heated in the reactor to 530°F, and uses this heat to generate steam in exchanger shell. Natural circulation carries the steam into a drum where cyclones remove moisture. Then steam goes directly to the turbines without superheating.

Designers make a considered departure

In selecting material for the heat exchanger tubes, the designers** were concerned with safeguarding against several forms of localized corrosion which might cause serious future difficulties . . . i.e., cracking or intergranular weakening caused by residual or service-developed stresses, alternate wetting and drying, chlorides or oxygen in the secondary steam cycle water.

In addition, on the reactor side, they wanted: (1) no build-up of corrosion products in the primary heavy water and; (2) no formation of galvanic couples that accelerate corrosive attack on one member or the other. On the steam side, they wanted to avoid any possibility of copper pickup.

After extensive studies and tests, alloys hitherto used in similar applications were ruled out in favor of Inconel alloy. Not only does Inconel alloy show up well on all the above counts, it also provides excellent strength at high temperatures. What's more, the low Cobalt content is desirable when maintenance eventually becomes necessary.

As for the tubing itself? The Huntington Alloy Products Division produces it . . . in lengths up to 85 feet and pre-bent. Every length is ultrasonically inspected. Orders are filled promptly.

If you would like more information on Inconel alloy write for our Technical Bulletin, "Engineering Properties of Inconel".

*Inco trademark

**Heat exchanger for NPD-2 was fabricated by Babcock & Wilcox (Canada) for The Canadian General Electric Co.

HUNTINGTON ALLOY PRODUCTS DIVISION
The International Nickel Company, Inc.
Huntington 17, West Virginia

INCONEL®

For more facts circle 299 on Reader Service card, p. 119

Gas turbines show their breeding

BROWN BOVERI

By R. L. Steer, Project Engineer, Brown Boveri Corp.

Brown Boveri gas turbines have the "solid" look of steam turbines. The casings are machined castings. The rotor shafts are large. Bearings and other parts are easily accessible. Each turbine has a single, rugged combustion chamber.

This family resemblance comes naturally. Brown Boveri gas turbines were designed from the start for continuous stationary service . . . in contrast to lightweight units adapted from aircraft engine designs.

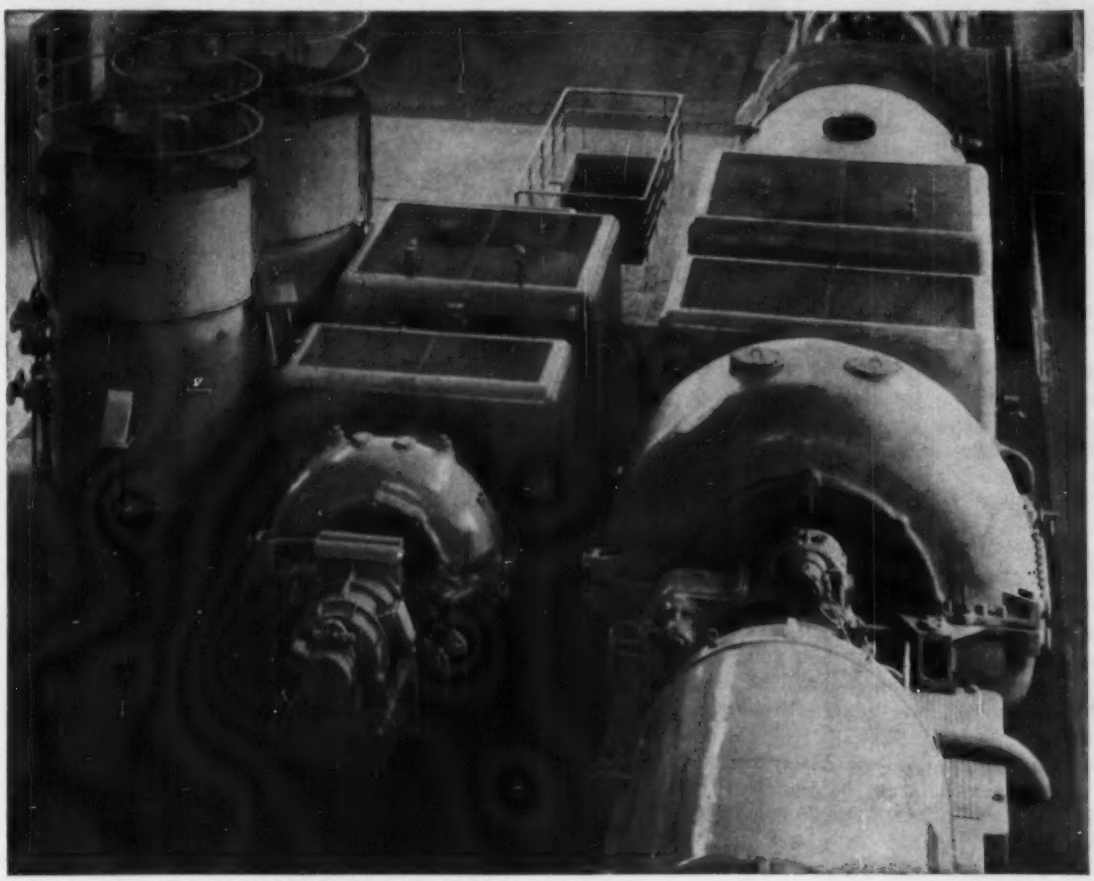
The first large gas turbine-generator, a 4,000 kw unit, was built by Brown Boveri and installed in 1939. It is still operating.

The world's largest gas turbine generating plant at Port Mann, Canada, is unattended! Its four 25mw Brown Boveri units are fully automatic and remote controlled.

Overhaul of two Brown Boveri gas turbine sets at the Pertigalete Cement Works, Venezuela, showed a typical condition: after 15,000 operating hours, components were almost like new. No sign of wear. No repairs or parts changes required.

Scores of Brown Boveri stationary gas turbines totalling over 1,300,000 kw installed capacity are driving generators, compressors and blowers in nearly continuous trouble-free operation—year after year. No other manufacturer can match this experience.

About Brown Boveri gas turbines: Sizes: 1,200 to 30,000 kw output. Single shaft sets for low initial cost. Double shaft, multi-stage units for lowest cost per kw and higher efficiency. Dual burners, quickly adaptable to gas or liquid fuels. Stationary, semi-mobile or mobile mounts. Completely automatic or remote controls.

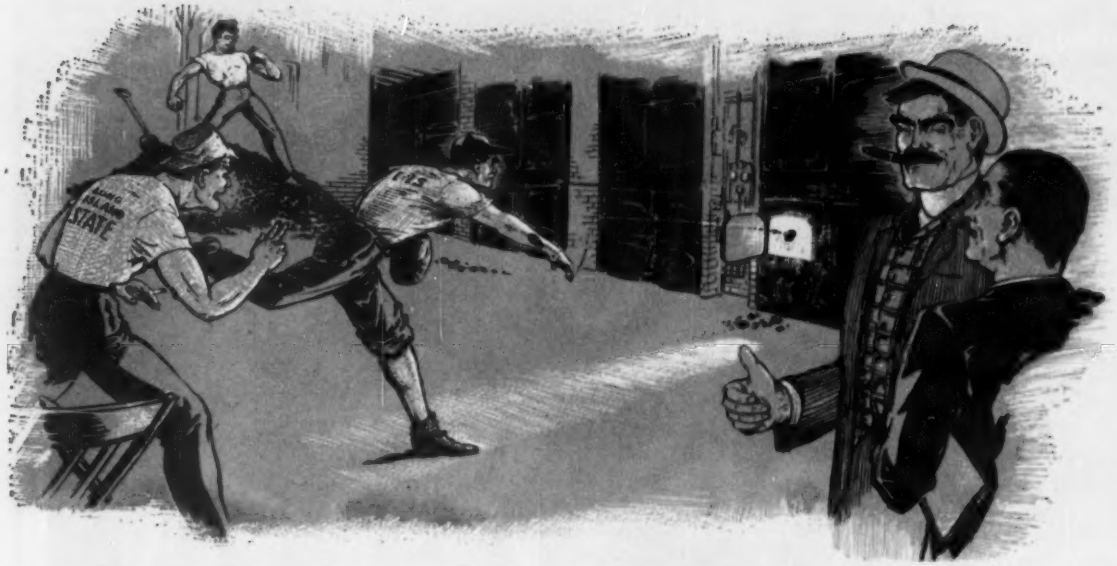


A Brown Boveri two-stage gas turbine. This turbine drives a 25 mw generator part of which is visible at the lower right corner of the photo. Starting time from cold to full load is less than 20 minutes.

BROWN BOVERI Brown Boveri Corp., Dept. P8, 19 Rector Street, New York 6, N. Y. Agents in 27 U. S. cities.

For more facts circle 300 on Reader Service card, p. 119

Marmy's balled-up furnaces



"Play ball," yelled the umpire, throwing down his shovel. And fast balls, spitballs and inside curves blazed into the roaring furnace

POWER editors receive the most interesting mail . . . from every corner of the globe. This morning a shift engineer writes asking what a "thimble" is. Seems it's a favorite question one examiner asks candidates for an operating engineer's stationary license.

I can think of several items called a thimble, both in engine rooms and boilers. But none of these may be the particular thimble the examiner has in mind. It was especially to do away with unimportant and hazy questions of this kind that our McGraw-Hill Book Co published *Standard Plant Operator's Questions & Answers* last year. If all examiners based their questions on specific engineering material indicated in reliable reference books, applicants wouldn't have to guess at what the inspector has in mind.

But just to make sure I wasn't out in left field, I called five chief engineers in our biggest plants here in New York City. Only two of them could name a thimble—and each described a different one.

Then I thought of asking that cantankerous consulting engineer, Marmaduke Surfaceblow. If *he* didn't know, then this question couldn't be worth a blown fuse.

I was lucky. When I arrived at the Bent Propeller, Marmy stood at the crowded bar, seemingly deep in thought. Tiptoeing up to the foxy old consultant, I asked as quietly as possible so as not to disturb his profound contemplations, "Will you describe a thimble, any thimble, just so it's important enough to be asked in an operating engineer's exam?"

"BILGEWATER on thimbles," that salty character suddenly roared in his foghorn voice, banging his left fist on the bar. "I'll tell you about a plant whose furnace bottoms erupted like Vesuvius because they navigated with a waterlogged crew."

That did it. Strong men put down their drinks and turned respectfully toward our hero. Marmy slowly ballasted his deeps from the bottle of Sandpaper Gin before him, then faced his expectant audience and roared.

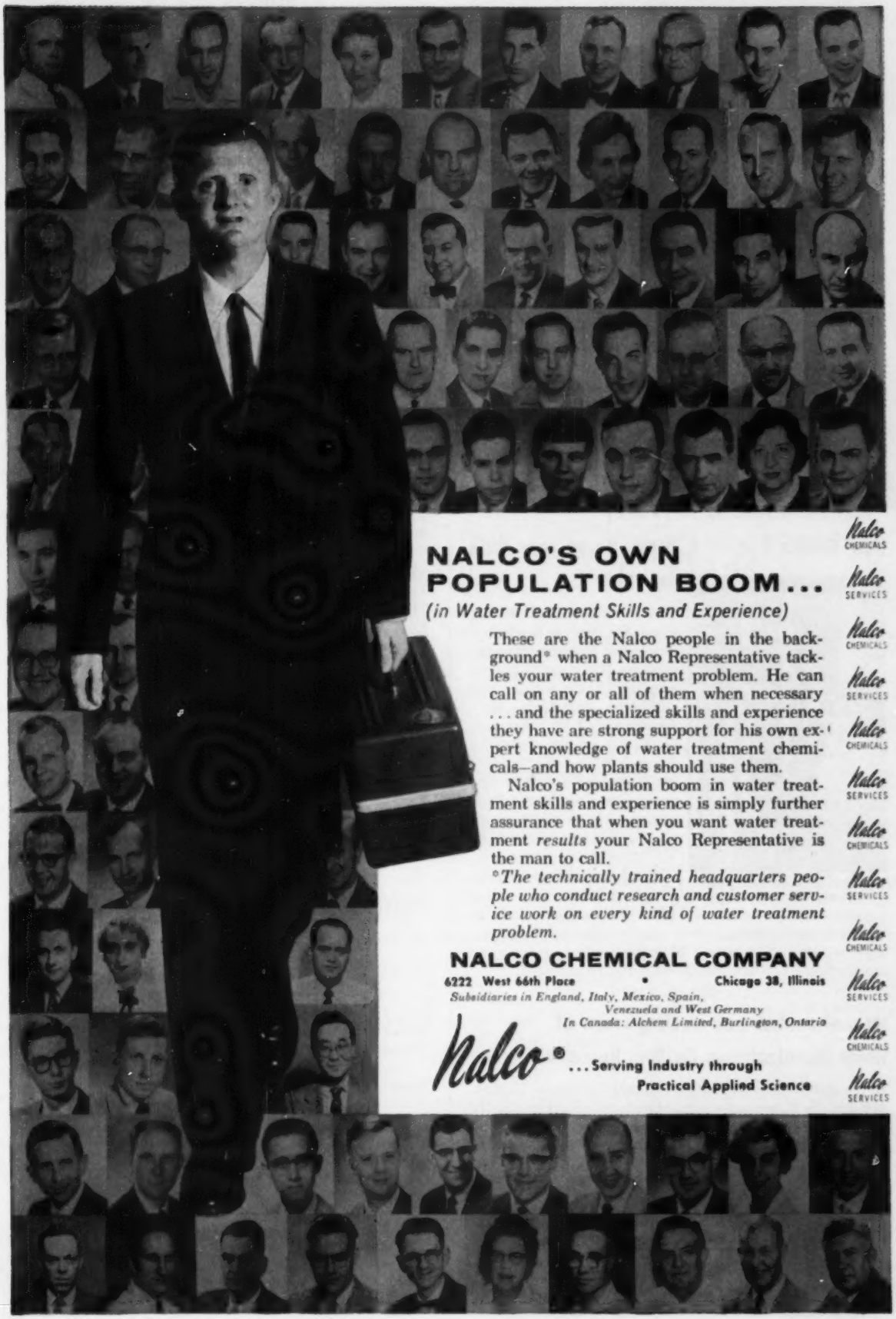
"Back in 1953 I got a call from my good friend Ted Peck of the Polyphase Chemical Service Co here in Manhattan. 'Marmy,' he chuckled into the phone, 'Ever been in a bughouse?'

" 'Not as one of the crew,' I answered.

" 'Good,' he shot back, 'how about driving out to the Long Island State Hospital with me in the morning? They have a tough furnace-slagging problem I'd like you to take a look at.'

"On the way out Ted told me they had four 400-hp hand-fired boilers. 'Don't be surprised at anything you see;' cautioned Ted, 'the super has to use what they call tractable inmates for help in the power plant.'

"An hour later we barged into the boiler room. But we stopped dead in our tracks. For a quick second I thought I was at Ebbets Field on the Brooklyn end of the Is-



NALCO'S OWN POPULATION BOOM...

(in Water Treatment Skills and Experience)

These are the Nalco people in the background* when a Nalco Representative tackles your water treatment problem. He can call on any or all of them when necessary . . . and the specialized skills and experience they have are strong support for his own expert knowledge of water treatment chemicals—and how plants should use them.

Nalco's population boom in water treatment skills and experience is simply further assurance that when you want water treatment *results* your Nalco Representative is the man to call.

**The technically trained headquarters people who conduct research and customer service work on every kind of water treatment problem.*

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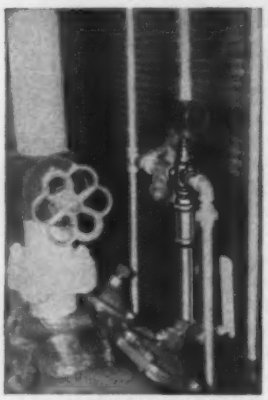
SARCO TOPICS

How to save water and prevent over-cooling of compressors, small engines, and hydraulic oil-coolers

When cooling water is controlled manually the operator frequently leaves the valve nearly wide open, in order to play safe if the load varies. The result is over-cooling. If he attempts to vary the flow of water he risks the danger of under-cooling. Automatic cooling controls assure proper cooling at *all* times and effect important economies in water consumption.

And here are three different experiences at Revere Copper and Brass plants which may give you some tips on solving your own cooling control problems.

How Revere Copper & Brass Saved over 50% on water



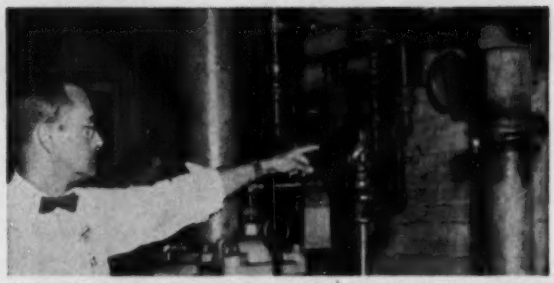
Sarco T-44 automatic cooling control installed at Revere's Riverside plant.

The Riverside, California, plant of Revere Copper & Brass was plagued by over-cooling of compressors. In addition, their water consumption was high — approximately 2,000 gallons an hour. By simply installing Sarco T-44 automatic cooling controls on the compressor cooling lines, plant engineers eliminated over-cooling and cut water consumption about 60%.

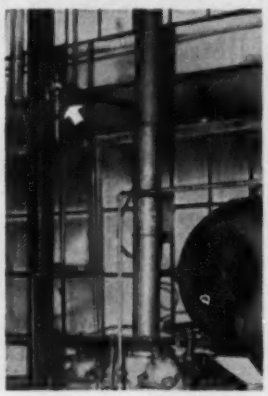
Another benefit was a saving in tool maintenance. (Originally excess moisture was causing difficulty with a large number of air screwdrivers used in the plant.) With the T-44's in service the maintenance problem has practically disappeared.

Manual control was wasting water at Rome Manufacturing Co. Div., Rome, N. Y.

At the Rome Manufacturing Company Division of Revere, at Rome, N. Y., cooling water for air compressors originally was manually controlled. When they installed Sarco T-44 automatic cooling controls on the cooling water lines they made substantial savings in water. They saved damage and maintenance cost on the compressors, too. That's because they eliminated the errors inherent in manual control. Automatic cooling controls always assure optimum cooling by permitting safe operation at the maximum temperature recommended for any given machine or process.



T-44 cooling control on compressor at Rome Manufacturing Co. Div. of Revere. Sarco sales representative Emlie Strickland points to control installations.



Installation of a Sarco T-44 on compressor at Rome, N. Y.

Water conservation program at Baltimore led to automatic control

Double target of engineers at the Baltimore plant of Revere was a water conservation program plus tighter temperature control. To achieve both objectives they installed Sarco automatic cooling controls on an air compressor, an aftercooler and a hydraulic oil cooler.

Results were so satisfactory they followed through by installing 50 additional Sarco controls.

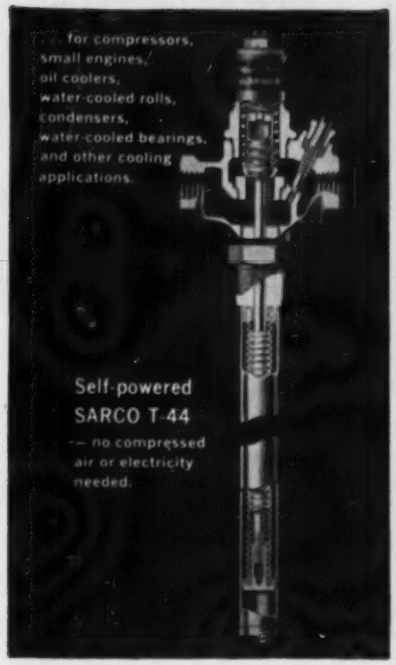
For more information on cooling control, contact your Sarco Sales Representative, District office, or write — 2169

SARCO

SARCO COMPANY, INC.
415 MADISON AVENUE, NEW YORK 22, N. Y.
PLANT: BETHLEHEM, PA.
STEAM TRAPS • TEMPERATURE CONTROLLERS
STRAINERS • HEATING SPECIALTIES

SARCO

Inside story on automatic cooling control


... for compressors, small engines, oil coolers, water-cooled rolls, condensers, water-cooled bearings, and other cooling applications.
Self-powered SARCO T-44
— no compressed air or electricity needed.

Simple, gadget-free design. Fully modulating. Sensitive liquid-filled thermostat gives you uniform movement of valve for each degree of temperature change, at all points on the range. Packless — no stuffing box — no leaks — no valve stem jamming. Self-contained — no part of mechanism exposed. Dependable and inexpensive — thousands in service. So reasonable in cost, you can afford Sarco automatic cooling controls for every application.

Sarco T-44 self-powered cooling control is available in standard 50° adjustment ranges: 60-110° F., 85-135° F., 110-160° F. and 135-185° F. Sizes: ⅜", ¾", ½" and 1".

For the full story on Sarco Cooling Controls...

contact your Sarco sales representative or district office, or write—

2148

SARCO

SARCO COMPANY, INC.
635 MADISON AVENUE, NEW YORK 22, N. Y.
PLANT: BETHLEHEM, PA.

Marmaduke

Begins on page 166

land—that was before my favorite team departed for the Coast. There was the center fielder perched on a mound of coal at one end of the boiler house, heaving chunks of coal to the pitcher, who turned out to be another fireman. The pitcher caught each lump in a baseball mitt, whirled around and blazed the lump for a called strike into an open firedoor of a furnace. The umpire was the third fireman, who sat in a chair in back of the pitcher, jumping up to call strikes between puffs on a cigarette.

"Ted and I stood there watching, hardly able to believe our eyes. Those boys were good, regular pros as ball players go. But as firemen they struck out the boilers and fuel consumption was losing fast.

"We watched fish-eyed as the baseball-happy firemen played at feeding the furnaces, Bob Feller style. Suddenly the super stood before us. He didn't even seem to notice the ball players. When Ted jerked a thumb at the firemen and asked what was going on, the super only shrugged.

" 'Oh, that's nothing new. We're operating on budget limitations, so I have to use inmates as firemen. Only way I can keep them feeding those boilers is to make them think it's a game. I'll get you some samples,' he said as he left. The ball game continued with no attention to us.

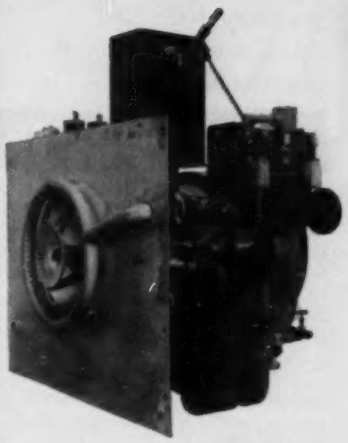
"Soon as the super gave Ted the operating-performance data and samples of slag he wanted, he shoved off.

"I walked over toward the pitcher to ask him about the condition of the fuel beds. But the umpire suddenly jumped up, grabbed a baseball bat leaning against his chair, pointed it towards the door and raved, 'To the showers, rookie, or I'll have ya sent back to the minors.' He seemed kinda sore, so I didn't stay to argue.

" 'Wow!' I yodeled, climbing back into the parked car as I wiped my forehead, 'I still don't believe what I just saw.'

" 'I've seen some screwy things in there,' answered Ted, 'but nothing as nutty as that.'

"The next week Ted sent his report to the super, recommending they control the slag deposit with a chemical



NEW . . . FABER'S COMPACT PACKAGE OIL-GAS-OR COMBINATION BURNER

Faber's rugged new "AF" Packaged Burner—field tested over 5 years' continuous duty—offers these advantages:

COMPACT • Unique space-saving design integrates burner, blower and controls. All components accessible for inspection or maintenance.

EFFICIENT • Unique axial flow, hollow shaft forced draft fan, adjustable curved vane air register and Voltrol fan inlet vanes for efficient turbulent fuel-air mix over wide range.

ADAPTABLE • Fan unit and "V" belt drive adjustable to heavier load for modest plant expansion. Motor, turbine or combination drive. Fully automatic, semi-automatic or manual controls. Standard electric drive with oil immersed gears and heavy duty motor develops 100 ft pounds of torque. Hydraulic or pneumatic controls available.

SAFE • Complete programming unit for flame safeguard, interlocked with safety circuit.

Write for Faber Catalog 59-1:
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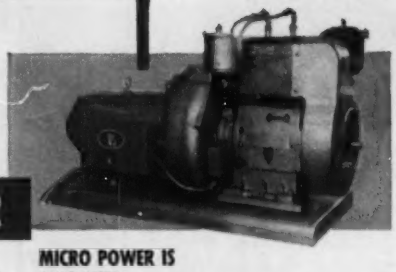
or any handy Faber dealership

FABER
ENGINEERING COMPANY, INC.

Manufacturers of Industrial Oil and Gas Burners, Fuel Oil Pump and Heater Units, Special Pumping Units, Since 1927

F-197

DOUGLAS AIRCRAFT
TULSA DIVISION . . .
assures effectiveness of its protective boiler flame controls with . . .



MICRO POWER

In plants like Douglas Aircraft Company, Inc., in Tulsa, Oklahoma, where a continual supply of steam is vital to production processes, every precaution must be taken to assure against the hazards of boiler flame-out. To safely regulate its burners in the event of flame-out, the company utilizes highly sensitive electric controls. Since these flame failure controls *are* electric and must depend on a constant, unwavering power supply for successful operation, this is achieved with MICRO POWER.

At Douglas Aircraft in Tulsa, Micro Power serves as the dependable rear guard to the boiler room. It provides a constant source of steady, independent electrical power as required by the safety controls, thereby eliminating voltage fluctuations and protecting against power failure.

MICRO POWER IS ALSO USED . . .

- on microwave systems for communications, for remote control, for telemetering.
- for refinery and chemical process indication and control.
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MICRO POWER PROVIDES . . .

- a constant uninterrupted source of electric power.
- voltage and frequency at usable value during transfers between motor and engine.
- stable voltage output.
- flywheel starting — no storage batteries.
- electrical isolation from commercial source voltage dips, peaks and breaks do not affect microwave equipment, no transfer switch.

For complete information on this and other Micro Power applications, write . . .

UNITED STATES MOTORS CORPORATION
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For more facts circle 304 on Reader Service card, p. 119

ASBESTON® INSULATION JACKETING
INSURES SAFER PROTECTION

U. S. Rubber's high quality, maximum performance asbestos insulation jacketing fabric. Available in both aluminized and non-aluminized finish for both indoor and outdoor applications. For further information wire, call or write Asbeston Department.

Textile Division
United States Rubber
Rockefeller Center, New York 20, N.Y.

additive. He also enclosed careful step-by-step instructions for shoveling five pounds of the stuff into each furnace once every 24 hours.

"A month later Ted called me again —he had an SOS from the hospital. We arrived there PDQ to find the super cleaning out his desk.

" 'Going on a fishing trip?' asked Ted good-naturedly.

" 'I'm leaving,' burped the super through his pipe, throwing tools, tobacco and papers helter-skelter into a bag. Then we learned that as soon as the additive arrived, the super turned it over to his pitching staff, giving them careful instructions. But those three professionals got into a huddle on the pitcher's mound and worked out a grand strategy that would hardly delay their ball game. It was major-league skulduggery, and a stroke of genius—for them. Getting down to work, they simply shoveled a 6-week supply of the new additive into No. 4 boiler in a few minutes.

" 'Play ball,' yelled the umpire, throwing down his shovel. And fast balls, inside curves, outside curves, knuckle balls and spitballs blazed into the furnace doors as one imaginary batter after another struck out.

"But two hours later No. 4 started to groan, wheeze and belch. Then a rumbling crash came from inside and the boiler house filled with soot, dust and smoke. The super quickly took No. 4 out of service. After the dust settled he looked inside the furnace. There was about a ton and a half of slag smothering his fuel bed. All that slag had come off the walls and tubes —and all at once. That's when the super got his walking papers. But the hospital's budget limitations stayed in effect.

"Nothing exciting happened there for some time after. About six years passed before Ted and I drove out that way again. We dropped in, but saw no ball players around. They had converted to oil firing.

"The new super was a self-styled efficiency expert, whose every second word was 'optimum efficiency.' He finally admitted he had noticed a gradual rise in stack temperature lately. It was clear to all of us that

For more facts circle 305 on Reader Service card, p. 119

circle 306 on Reader Service card, p. 119 ➤

COPPUS BLUE RIBBON PRODUCTS

Coppus Vertical Steam Turbine

THE MARK OF QUALITY — There's no better test of a turbine's quality than performance. And the new, ruggedly designed, power-packed Coppus Turbines pass all performance tests with top honors! Small wonder. Coppus quality is literally designed and built into them. Their super stamina is the end-product of painstaking craftsmanship, finest materials and methods, thorough testing and control. Each truly deserves its Blue Ribbon . . . assurance of *complete* reliability.

Typical Coppus Blue Ribbon features are: *totally enclosed governor . . . totally enclosed and independently operated safety trip . . . easily replaceable packing and bearings . . . multiple steam nozzle control . . . brake rim for added safety . . . wide bucket "L" type wheel (optional) for minimum water rate.* You get higher efficiency operation . . . less down time . . . lower maintenance costs.

Coppus Turbines are built to customers' specifications, including API and NEMA standards. Send for Catalog 200. Get complete details on Coppus Turbines. Sizes from 1 HP to 250 HP. Write COPPUS ENGINEERING CORPORATION, 168 Park Avenue, Worcester, Mass. Sales Offices in *Thomas' Register*.

COPPUS
STEAM TURBINES

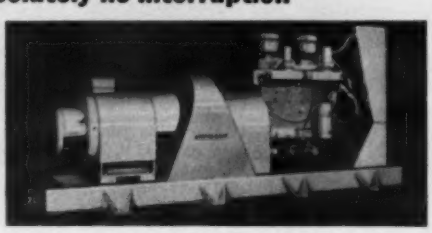
Where
in your plant
can a 7-second
power loss
mean
DAMAGE?
DOLLARS?
DANGER?

A certain drug manufacturer has only 7 seconds to live in case of power failure. In areas where powders are pressed into pill form, special ventilating fans are a critical part of the manufacturing operation. Power failure that would stop the fans for even 7 seconds would raise the dust level to the point of spontaneous explosion . . . wreck buildings, demolish equipment, destroy human lives.

While most manufacturers are not faced with this multiple extreme, any company whose operation is even partially automated faces this truism: Power loss for even a few seconds spells damage, danger and dollars.

Power with absolutely no interruption

Condec's UPS (Uninterrupted Power Supply) eliminates this problem completely because it provides power without interruption, full voltage restoration in 1.5 milliseconds. Frequency is maintained within 1% during operation, within 3% in transition. Synchronization is automatic, operation is unattended. Units from 5 to 200 kw.



Where UPS can help you

Wherever your manufacturing depends on power, Condec's UPS wipes out the hazards of danger, damage or dollars that can be caused by even 1-second power losses. For more information, or a free demonstration at our plant, write or call Mr. Frank Cesario, Consolidated Diesel Electric Corporation; telephone DAvis 5-2261.

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CONSOLIDATED DIESEL ELECTRIC CORPORATION
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Marmaduke

Begins on page 166

fire scale building up on the tube surfaces was cutting down heat transfer, sending his Btu's to heat the clouds. After Ted argued that chemical additives couldn't possibly damage boiler refractory or metal, the super finally agreed to treat one boiler, leaving another untreated as a control.

"Four months later, stack temperatures on the treated unit had returned to normal. Evaporation rose about 0.4 lb, enough to pay for the additive and shell out dividends on decreased oil consumption besides.

"But then we examined her refractory. Instead of having a yellow, dull appearance, it was bluish black. Small, highly refractile bluish-black crystals were imbedded and it was pitted here and there with ½-in. sinus cavities.

" 'What do you think?' asked the super as we examined those pieces.

" 'I've run into this before,' said Ted, shaking his head. 'Looks like your poor-grade floor refractory has become infiltrated with vanadium.' Next day his lab tests proved him right. Ted called me.

" 'Don't forget,' Ted reminded me, 'their refractory is such cheap stuff that it won't stand up against semi-molten slag. Add that to running a plant on budget limitations, having work done by the lowest bidder and operating with a team of tractable inmates—and what can you expect?'

"So Ted drove out there and explained to the super, 'Your refractory is gradually dissolving and being replaced by a vanadium-rich slag. When the refractory cools, there's crystallization inside. On heating, the crystals melt. So alternate heating and cooling, melting and crystallization set up strains and stresses inside your refractory. Do you know what's going to happen?'

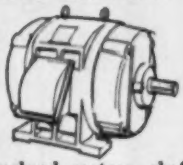
" 'What?' asked the super suspiciously.

" 'Your entire floor is going to heave up.'

" 'Ho, ho, ho,' roared the super, 'that's a nice theory, but I don't buy it. It's your chemical additive that's causing the damage, and I think your firm should replace the 5-year-old floor you guys ruined with your ex-

CONDEC
Products for Power

Lima Electric Motors

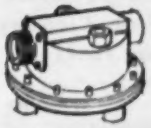


Electrical drives for any application in the 1-to-200 horsepower range. Over 8,000 different combinations of electric motors, gear reducers, gearhead motors, shaft mounted speed reducers, selective speed drives and variable speed motors.

Hammond Valves

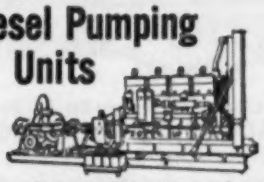
. . . A full selection of 550 models of gate, globe and check valves in bronze. Designed and produced to meet the most demanding specifications for industrial, government, domestic applications.

Consolidated Controls



. . . Precision instrumentation and control systems and their components including a complete line of pressure switches — from inches of water to hundreds of atmospheres — for controlling an electrical circuit in response to a variable pressure.

Diesel Pumping Units



. . . Complete pumping systems for crude oil, refined petroleum products, water and other fluids for continuous or emergency service. Stationary or mobile units.

A facilities and product brochure has been prepared to tell you in greater detail about THE CONDEC GROUP. Send for it today.

THE CONDEC GROUP*

*Consolidated Diesel Electric Corporation
880 CANAL ST. • STAMFORD, CONN.
And its Subsidiaries:
Consolidated Avionics Corp., Westbury, N. Y.
Consolidated Controls Corp., Bethel, Conn.
Hammond Valve Corp., Hammond, Ind.
The Lima Electric Motor Co., Inc., Lima, Ohio
Ultradyne, Inc., Albuquerque, New Mexico
© Consolidated Diesel Electric Corporation, 1960

Marmaduke

Begins on page 166

periments,' he added, pounding his desk.

"'It's easy to see if the additive is the culprit,' replied Ted calmly. 'Just inspect the 5-year-old control furnace and you've got the answer.'

"'That means removing about 20 bricks set into the firedoor as an insulation seal,' argued the super. 'I won't do that.'

"But when Ted predicted that the floor in the control boiler could be expected to heave within the next six months as it was installed at the same time as the floor in the damaged boiler, the super was sold. He ordered the seal removed.

"The super took one look inside and yelled, 'Holy cow—she's *already* erupted!'

"'Yes,' agreed Ted, 'and you have never used an additive in there.'

"Last week the two of us drove out that way again. Stepping into the boiler house we froze in our tracks. A gang of slap-happy inmates was banging away with hammers and wrenches on sheets of metal as they carried them into a furnace. Sounded like a Fourth-of-July parade of kids using wash tubs for band instruments.

"'What goes?' asked Ted when the super came out of his office.

"'I think I got the furnace floor problem solved for good this time,' answered the super as he gave me a sly wink. 'Instead of replacing those floors, I'm covering them with sheets of ceramic-coated metal used in exhaust tailpipes of jet engines. The coating is aluminum oxide, zirconium silicate and zirconium oxides sprayed on about fifty-thousandths of an inch thick. It stands up to 2200 degrees.'

"Ted and I didn't say anything—we just stared at those inmates, listened to the music—then walked quietly back to the car.

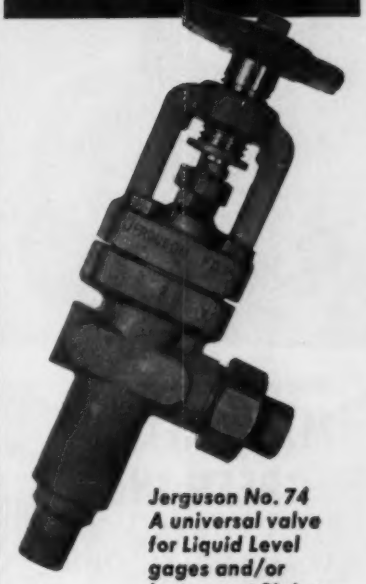
"'Now I *have* seen everything,' Ted said, soon as he backed out of the parking lot.

"'Well,' I added, 'long as their plant operates on budget limitations, it means using tractable inmates, the poorest grade of refractory and a superintendent who lines furnace floors with sheet metal. It all adds up to one crazy ball game—but at skyrocketing costs.'

"'Amen,' answered Ted.—*SME*

continued

Here is a NEW Jerguson ALL-PURPOSE ANGLE VALVE



Jerguson No. 74
A universal valve for Liquid Level gages and/or Instrument Piping and General Use

This unique New Angle Valve has unusual advantages. A universal valve, ideal for liquid level gages . . . simply add our pipe plug with integral bleed (No. 74G) for the ideal valve for instrument piping and general use.

Combines Advantages of single-piece forged body and bonnet flange, simplified OS&Y bonnet and reciprocating stem in one valve.

Forged yoke supports stem away from valve body; separate forged gland-follower bears on packing, independent of yoke. Stem thread outside, not affected by temperature or liquid. Stem works freely, no chance of freezing.

Reciprocating Backseating Stem: Works in to-and-fro motion with no rotating action; gives perfect seating, eliminates wear from galling. Backseating eliminates packing contamination from liquid; can be repacked under pressure. Teflon seating available.

Write for catalog sheet on Jerguson No. 74 Valve.

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Gages and Valves for the Observation of Liquids and Levels
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DESIGNED FOR STEAM TURBINE TESTING

TYPE WG DEAD WEIGHT PRESSURE GAGE

Please request data sheet 593

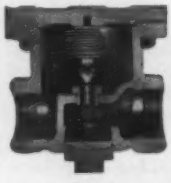
MANSFIELD & GREEN INC.
1051 POWER AVE.
CLEVELAND 14, OHIO

circle 309 on Reader Service card, p. 119

Sooner or later you too will be trapped by RIGGIO (why not now)

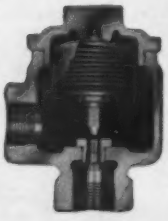
RIGGIO
THERMOSTATIC STEAM TRAPS

pressures from Vacuum to 250 lbs.
Semi-steel Construction
½", ¾", 1", 1¼", 1½", 2"



TYPE B-250

pressures from Vacuum to 200 lbs.
Bronze Construction
½", ¾", 1"



TYPE A-200
Freeze-Proof

Simple
Rugged
Versatile
Tight Shut-off

For additional information contact

FRANK D. RIGGIO CO., INC.
State Highway 17, Rutherford, New Jersey
Phone Webster 9-8450

Marmaduke

Begins on page 165

Marmy's mailbox

LIKES PROBLEMS

I always get a kick out of our old friend Marmaduke. His stories involve some sort of problem just a little offbeat and not usually seen by the run-of-the-mill engineer. I'm very much interested because of his inimitable style and because most of the problems he solves result from carelessness or error of the operators or equipment builders.

C G HANSEN, *Sausalito, Calif.*

POWER & MARMY

Have enjoyed POWER and the Marmy stories while sailing in the merchant marine, as a combustion-control technician and while in related fields. POWER has helped me over the years to absorb knowledge I couldn't have gotten from any other source. And of course Marmy is always frosting for that great big wonderful cake known as POWER.

H L HUTCHINS, *Long Beach, Calif.*

MARMY GOOFED?

Marmy goofed in the Sept 1959 issue. I've been waiting to catch him in a technical error. Now, at long last—his error is geographical. He told us the *SS Renshaw* passed Bantry one night rounding England. It's on the southwestern tip of *Ireland.*

N R LAWLESS, *Co. Wicklow, Ireland*

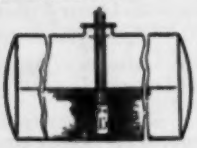
EDITOR'S NOTE: *Yes, but he said it with an Irish accent.*

REMPE
Heat Transfer Equipment

"HOT SPOT" PREHEATER

FOR HEAVY OILS AND LIQUIDS IN BULK STORAGE

Preheats fuel oils and other liquids to proper flow temperature before entering the suction line.



Heats with Steam or Hot Water

The Rempe "Hot-Spot" does an efficient preheating job . . . releases more BTU'S from fuel oils. Special flow accumulator causes liquids to pass over heated coils. Takes the load off the suction pump.

All steel shell and coil assembly—14" or 16" shell diameters—Connections furnished correct length for any tank diam.

TANK HEATERS

For Plating, Rinse, Cleaning and Caustic Tanks

EFFICIENT • HIGH SPEED
SOLUTION HEATING

Coil illustrated is the Rempe Hi-Therm Grid designed for fast load pickup on all liquid heating jobs. Coil style is an exclusive Rempe Pattern. Available in steel, copper and stainless steel.

Maximum prime surface increases fluid turbulence making the Rempe Grid far superior to plate type coils.

WRITE FOR BULLETIN

Engineering Data Book
Pipe Coil and Fin Coil Designs. Heat Transfer Coefficients. Get a copy for your library.

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circle 310 on Reader Service card, p. 119

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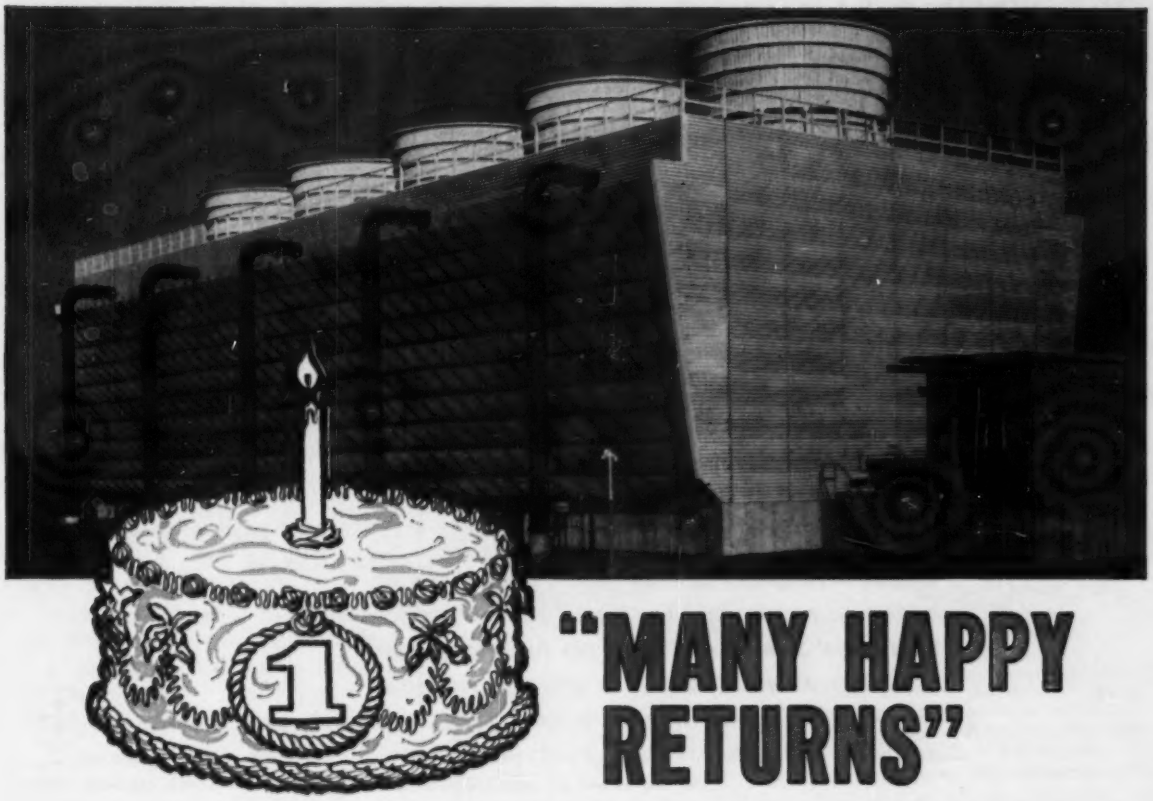


"MANY HAPPY RETURNS"

This Class 600 Marley Double-Flow cooling tower is one year old . . . and in excellent condition functionally, mechanically and structurally. To assure many more "happy" anniversaries over a long future, The Marley Company will never relax vigilant attention to every detail of its welfare.

Like all Class 600 towers, it will be under the surveillance of a member of the Marley Service Engineering staff, experts on cooling tower operation and maintenance. The results of their services are best attested by supervisory engineers and executives in plants where Class 600 towers are now in service:

ENGINEER, GENERATING STATION:

"We have greatly appreciated the service you have rendered. We had little experience with towers before these four units were put in operation, but we have received much help from your service engineer. Periodic inspection by someone who knows towers relieves us of the worry of letting our towers degenerate. Our supervisors always look forward to these visits and have plenty to discuss with your engineers. Your service has been good and we hope we can continue along this way with the new tower which you will soon be building here."

MANAGER, NUCLEAR PLANT:

"It is our opinion that mutual benefit has been derived from the periodic visits of your service engineer. We know that this service has given us experienced assistance in operational, mechanical and wood deterioration problems."

REFINERY ENGINEER:

"The Marley service engineer has been a most helpful person to work with and has always been ready to come and help us. His recommendations have been fair, honest and unbiased. That is why we have always accepted them. We would be very disappointed if this service was not available; we have come to depend on it."

MUNICIPAL POWER SUPERINTENDENT:

"From the power plant operator's point of view this is the best service you can give! I will welcome your service engineers at all times. There are many pieces of equipment in a power plant and it is impossible to give each piece of equipment the loving care that the manufacturer would like it to have. Therefore, I welcome an opportunity to discuss, with service engineers, the operation and maintenance of any piece of equipment in the plant. Your service engineers have been most courteous and helpful. I hope that I shall see more of them in the future."

PETRO-CHEMICAL PLANT MANAGER:

"We have found the attention of Marley service engineers beneficial to our cooling tower operation and maintenance. In particular, we appreciate the latest inspection of our towers. This service has been helpful to our preventive maintenance and cooling tower repair programs. We are looking forward to working with your engineer during an early visit."

THE MARLEY COMPANY MARLEY KANSAS CITY, MISSOURI

For more facts circle 312 on Reader Service card, p. 119

GOOD NEIGHBOR POLICY IN PLUMBING:

How the boiler room of the Hudson Bay High School also serves the school across the street

And a neighborly boiler room it is! From it, 100,000 feet of USS National Pipe, in the form of steam heat, plumbing, air and fuel lines, serves not only the Hudson Bay High School, Vancouver, Washington, but is used to pipe steam across the street to a vocational school, too. USS National Pipe in sizes from ½-inch through 12 inches was used.

Do you need quality pipe for power, heating and air conditioning installations? You'll get it when you ask for USS National Steel Pipe. If you'd like further information, or immediate assistance with your pipe problems, write to National Tube Division, United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS and National are registered trademarks

This mark tells you a product is made of modern, dependable Steel.

Plumbing & Heating Contractor: Longview Plumbing & Heating Company. Mechanical Design: J. Donald Kroeller & Associates, Consulting Engineers.

The world's largest and most experienced manufacturer of tubular products.

USS National Tube Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
United States Steel Export Company, New York

Maintenance and Steam Traps

. . . there's a relationship that goes far beyond trap maintenance alone

Good traps and good trapping have a greater effect on your maintenance costs than does trap maintenance itself. By that we mean that the right traps, properly selected and installed, and with the benefits of a preventive maintenance program, will save far more maintenance dollars than they will cost.

Under the pressure of spiralling maintenance costs, this thought becomes mighty important. Let's take a look at what it involves:

Proper Selection of Steam Traps

1. Be sure it's the right type of trap.

2. Be sure it's sized right and is for the correct operating pressure.

3. Be sure it's first rate in design and construction.

Proper Installation of Steam Traps

1. Install them so they are accessible for inspection and maintenance.

2. Install a test valve.

3. Use a union or unions.

4. Use a shutoff valve or valves.

5. Use a strainer ahead of the trap if dirt conditions are bad.

6. Use a by-pass only where continuity of service is imperative.

7. Standardize inlet and outlet connections.

Preventive Maintenance Program

1. Test trap regularly for proper operation. (Trap size, operating pressure and importance determine frequency.)

2. Inspect internal mechanism at least once a year.

You Get Indirect Benefits As Well

The direct benefits of the plan outlined are pretty obvious — good traps, properly selected, require less maintenance . . . testing and inspection prevents troubles that lead to maintenance.

However, this plan provides indirect benefits which reduce maintenance in other parts of the plant as well:

Good traps save steam and reduce the load (and consequently maintenance) on fuel handling and burning equipment and on ash handling equipment.

Good traps protect the system by eliminating water hammer and preventing the damage it can do.

Good traps discharge carbon dioxide before it can go into solution to form corrosive carbonic acid — less corrosion, less maintenance.

Good traps increase production to reduce the length of time equipment must operate or reduce the amount of equipment needed . . . either way maintenance is reduced.

How to Go About It (The Sales Pitch)

We admit we're prejudiced, but we don't think there is any better way to select steam traps than with the help of the 44 page Armstrong Steam Trap Book. Here in a single source is specific data on the selection and sizing of traps, how to install them for best results, and how to maintain them most economically.

The Steam Trap Book will also give you full information on the design and construction of Armstrong Inverted Bucket Steam Traps that offer these important maintenance-reducing advantages:

1. Armstrong Traps are dependable.

2. Armstrong Traps require no adjustments — go from full load to zero load automatically.

3. Armstrong Traps are self-scrubbing—ordinary dirt conditions can't hurt them.

4. Armstrong Traps have long-life parts — valve and seat are heat treated chrome steel — lever assembly and bucket are stainless steel.

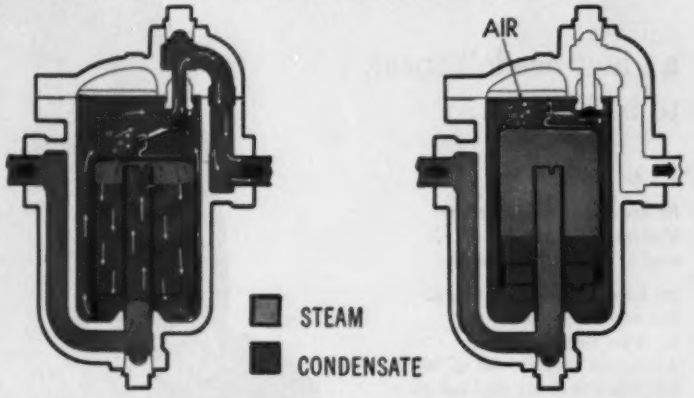
5. Armstrong Traps have water sealed valves to minimize wire drawing and erosion.

Ask for your copy of the Steam Trap Book—there is no obligation. Then test Armstrong Trapping. If you are not completely satisfied with the results, you can return the traps for a full refund of the purchase price. You can't lose much that way. Call your local Armstrong Representative or Distributor, or write

Armstrong Machine Works
8128 Maple Street
Three Rivers, Michigan

ARMSTRONG STEAM TRAPS

HERE'S THE STEAM TRAP DESIGN THAT CAN REDUCE YOUR MAINTENANCE PROBLEMS



Trap open. Condensate entering trap has caused bucket to lose buoyancy. Weight of bucket times leverage pulls valve open. Air is discharged along with condensate.

Trap closed. Steam has floated inverted bucket; valve is held tightly closed by system pressure. Air entering trap passes through bucket vent and accumulates at top of trap.

See our catalog in Sweet's Plant Engineering File

For more facts circle 314 on Reader Service card, p. 119

a giant needn't speak to be heard...

. . . he need only be a giant.

he need only do the things
that only a giant can do . . .
and he will be listened to.

we have a giant of our own.
his name is diesel.
he is an engine—
a supplier and creator of power.
his jobs are many and varied,
his demands are infrequent and few.

in an emergency
he can work on almost any fuel.
on assignment
he can work almost anywhere at all.

he makes the boats go . . .
towboats on the Mississippi,
harbor boats in Pakistan,
fishing fleets out of Portugal,
tuna clippers off Peru.
in wartime he drove submarines
and landing craft.
today he helps atomic vessels
do their job.

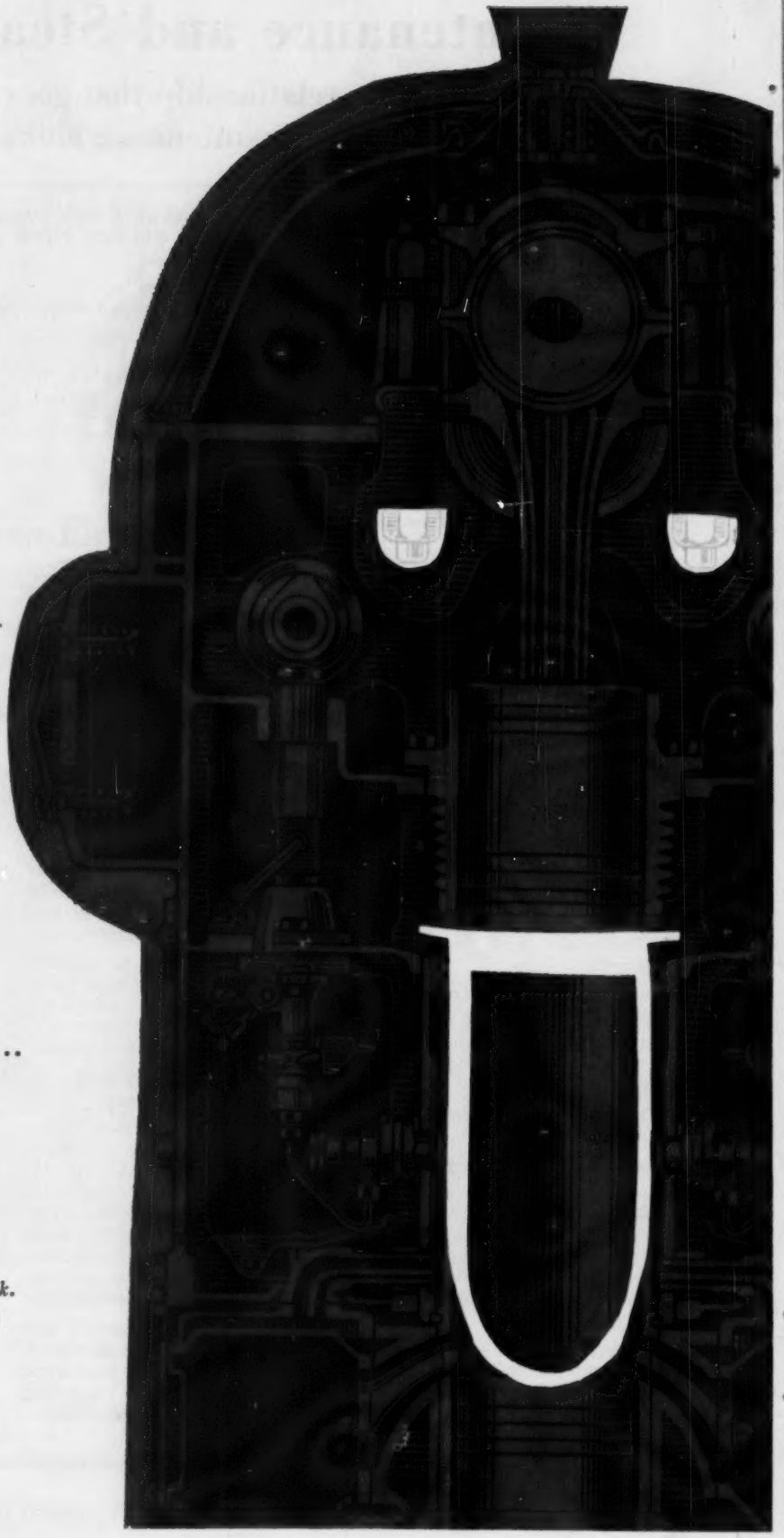
he drives . . .
cement mills in Indonesia,
dredges in Manila Bay,
oil drills in Venezuela,
rigs in the Gulf of Mexico.
he pulls buses, trucks and tractors . . .
locomotives, rock-crushers
and bulldozers.

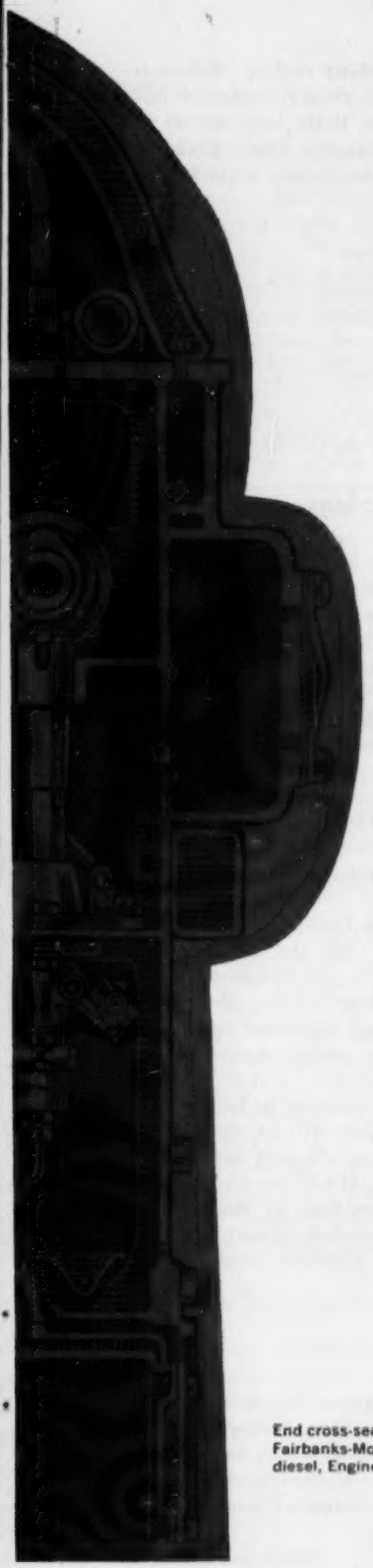
he generates . . .
light for cities
and power for plants,
electricity for homes
and more for hospitals.
he powers
missile stations in Wyoming,
radio stations in Sudan
and emergency stations in New York.

there is no country in the free world
where he is a stranger.

there is nothing he will not tackle
and little he cannot do.

his voice is in his accomplishments
and you hear it every day.





From Beloit to Bangkok—Fairbanks-Morse diesels are known, respected and relied on. They can be tailored to available fuel. They handle heavy loads in short periods of time. And they provide low-cost electricity for almost every situation you can think of. Their minimum weight, lack of vibration and simplicity of construction are further guaranteed by our 24-hour service the world over. There is no other producer of power more universally accepted than our diesel.

If your business demands effective, dependable and economical power—you will be interested in learning more about our complete line of diesel engines.

Write to: Diesel Division, Fairbanks, Morse & Co., Beloit, Wisconsin.

Fairbanks, Morse

A MAJOR INDUSTRIAL COMPONENT OF **FAIRBANKS WHITNEY CORPORATION**

End cross-section of the Fairbanks-Morse Opposed-Piston diesel, Engine No. 38D8-1/8

For more facts circle 315 on Reader Service card, p. 119

Powerscope . . . A selective look at

Materials get critical eye

The Advanced Research Projects Agency, Dept of Defense, has contracted with three universities to set up enlarged programs for basic research in the science of materials; they are Cornell, U of Pennsylvania and Northwestern. Cornell will get $6.1 million for the first four years of the program, will organize a Materials Science Center and train PhD research scientists in materials. Solid-state physics will cover imperfections, transport processes, magnetic resonances, internal friction, photochemical processes, surface phenomena, ferroelectrics, ferromagnetism, many-particle theory and thermal conductivity. Physical chemistry covers electron and X-ray diffraction, inorganic polymers, solid-vapor reactions, electronic process, diffusion, etc. A third area covers metallurgy and a fourth mechanics of materials. Faculty will be increased from about 30 to 60 in the next ten years.

Another energy source

Experiments made by Energy Conversion Laboratories of Denver, Mich. show that constant streams of highly reactive *free radicals* can be made in seemingly self-sustaining systems. They react at near room temperature with their bursts of chemical energy convertible directly to electricity and other forms. The Laboratories have not revealed their invention, but claim it will be able to work in self-contained packaged power units without moving parts, and run continuously. They predict it can be used for stationary and portable power generators, desalting sea water, boats, trucks, tractors and automobiles.

Power milestone

The American Electric Power System has been the first one in the world to produce over 30-billion kwhr in a 12-month period. They produced a total of 30,027,858,000 kwhr ending April 30, 1960. This compares with 709.5-billion kwhr for all public and private utilities in the U.S.A.

OG&E adds more gas turbines

Oklahoma Gas & Electric Company plans to install a 200+ mw unit in its Horseshoe Lake Station using a combined steam-gas-turbine cycle. The General Electric unit will have the gas turbine exhausting into the boiler furnace as well as generating electric power. Cycle will be at least 4% more efficient than conventional-steam-plant cycles. Schedule calls for a 1963 start. OG&E installed 3.5-mw gas turbines in its Belle Isle Station in 1949 and '52 for feedwater heating of the steam units and supplementary capacity.

Bookless libraries

A F Glimn and R D Greenway of General Electric Company predict that electronic libraries will be a reality within five years. Information-system techniques are verging on breakthroughs that will solve the application problems. It's a matter of economics, but soon it will be feasible to carry huge libraries of information in on-line digital-computer storage.

Russia lays expansion plans

U.S.S.R. hopes to raise its 264-billion kwhr of 1959 to 2.3-trillion kwhr by 1980. They expect to install 12-million kw annually to 1965 and 20- to 25-million kw after that. Only three types of standardized thermal plants will be built: 1200, 1800 and 2400 mw. They will be erected in three to four years, of prefabricated concrete parts. The U.S.S.R. is now building 80 new factories to manufacture power-plant equipment. Present turbine capacities are 200 and 300 mw. Plans are being laid to build 600- and 800-mw units with 1000 mw expected in the future. A 1400-kv dc transmission line will carry power from Siberia to industrial centers in the east.

Arizona Public Service Company has signed a 35-year agreement with the Pittsburg & Midway Coal Mining Co of Pittsburg, Kan. to supply its new 110-mw Cholla plant near Joseph City, Ariz. A new open-cut mine west of Gallup, N. M. will be opened to supply ultimately 1-million tons of coal a year. Cholla Power Plant will start running in late Spring 1962 when the new mine will be ready, too. The plant will be Arizona's first large coal-burning power station. It will use about 380,000 tons annually supplied by 86-ton rail cars. Availability of coal is expected to increase its use beyond Cholla's needs in the Southwest area.

U.S.S.R. dreams?

A Swedish electrical engineer named Conradson returned from Russia in 1955 and reported on experiments he had witnessed in Russia with "cableless" power transmission. He had worked on so-called "transmitting" transformers. Before leaving

Russia he was told the experiments were a failure —but he thinks the Reds were bluffing. In 1957 a Turkish engineer, Ezameri, told of Russian experiments he had witnessed in transmitting high-tension electricity without cables. The Moscow publication *Technical Practice* now predicts that by 1965 some Moscow governmental buildings will get their current by special "reception" transformers. The scheme is attributed to physicist Professor Iwan Horun. (*McGraw-Hill World News*)

The Federal Bureau of Mines celebrated its 50th birthday on July 1. The Bureau was created when coal-mine disasters were killing many workers. In the ten preceding years an average of 364 coal miners a year died in disasters. Now about 32 miners a year lose their lives — safety record has improved vastly. The Bureau has contributed to improving coal-burning efficiency in power plants. Bureau studies paved the way for safe ventilating systems as used in New York City's Holland Tunnel and provide information for reducing air pollution from engine exhausts and incinerators. The Bureau has published nearly 8000 reports on work done in minerals, mineral fuels, industrial health and safety. Bureau researchers have published an equal number of articles in scientific, trade and technical presses of many countries.

New load-dispatching center

Public Service Electric and Gas Company has placed the largest dispatching board in the U.S. at its Terminal Building, 80 Park Place, Newark. The board is 10½-ft high and 210-ft long, attended by three dispatchers. Each load dispatcher has a console with 100 telephone lines for communicating with points on the system—these are the largest of their kind in the U.S. Six magnetic-tape units run constantly at the center recording all telephone conversations. In addition to the usual electric instruments the center also has weather indicators for: wind vanes, wind velocity, barometric pressure, temperature and humidity.

What's the weather?

National Science Foundation has entered into a $500,000 research contract with the University Corporation of Atmospheric Research to establish a national center of atmospheric research. The center will have a central scientific group to stimulate and supplement university research. Research programs will probably be of four types: (1) atmospheric motions (2) atmospheric energy-exchange processes (3) atmospheric water (4) atmospheric physics. The center's staff will have researchers from physics, chemistry, engineering, meteorology, etc. Members of UCAR are Arizona, California, Chicago, Cornell, Florida State, Johns Hopkins, MIT, Michigan, NYU, Penn State, St. Louis, Texas A&M, Washington (Seattle) and Wisconsin.

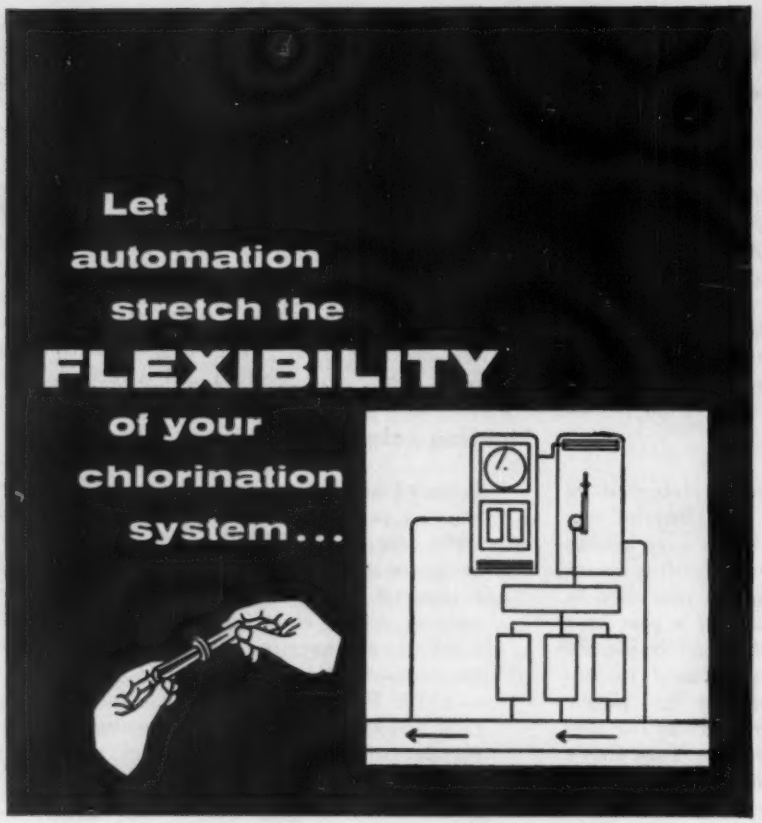
Starting salaries

Lehigh University reports an average monthly starting salary for all its 1960 graduates of $493 compared to $485 a year ago. The average for all its engineering graduates is $525 compared to $495 last year. Averages by courses were: electrical—$540, mechanical —$528, engineering physics—$525, metallurgical—$520, chemical—$515, industrial —$510. Personnel men from 340 companies held 7843 interviews with 520 seniors. Greatest demand was for mechanical engineers; 178 companies interviewed 38 seniors.

Desalting research

A pilot plant in the Dow Chemical Company's Texas div will be used in a joint research program with the government. This will investigate pre-treatment of saline water to minimize scale formation in vapor distillers. It seems that as sea water is evaporated to one-fourth its volume, precipitation of calcium sulfate may be prevented by a partial ion-exchange softening of the feedwater, using evaporator blowdown as the resin regenerant. The U.S. Navy will supply a 4000-gpd distiller with which to do the research. The Office of Saline Water is paying about $65,000 as part of the contract.

Cleaver-Brooks Special Products has been awarded a contract to build the largest seawater conversion plant in the U.S. and its possessions. The 275,000-gpd plant will be installed on St. Thomas in the Virgin Islands. The $200,000 contract was awarded by the Virgin Island Corporation, a subsidiary of the Department of the Interior. Plant will have 28 stages and use the flash-evaporation principle. St. Thomas now imports its water by barge from Puerto Rico; water plant will eliminate the barging operation and reduce water costs by nearly 75%. Unit will be powered by steam extracted from a power-generating steam turbine. It will run under complete automatic control. Plant is scheduled to be delivered in February 1961.



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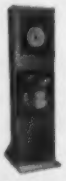

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Powerscope

Begins on page 180

Technical communication problems outlined at NYU

New York University's Office of Special Services to Industry and Business recently gathered engineers, scientists and press men to discuss problems and new techniques for getting technical info spread thoughout "The Critical Million." This Critical Million was described by Dr J R Pierce, Bell Telephone Lab director, as that segment of the population composed of engineers and scientists—a well-educated, intelligent group, basically honest but a little skeptical. Although this group may be pinpointed and described as a body, its size and diversity create a problem when each individual has to be informed of the complex technological details and latest results achieved throughout the field.

Dr Pierce and B MacKenzie, IBM Corp director, agreed that the information officer should be trained in the field he is representing — he should be an engineer or scientist. He should be a specialist since he deals with a specialized group. The information officer could also be a little more straightforward and a little less polite, and should not hesitate to criticize.

Science journals were agreed upon as the most informative published material. These *present* scientific results whereas the trade journal tends to *interpret* results. Newspapers pinpoint and *spotlight* results.

According to F Coss, vice-president of Scientific Technological Communications, Inc, communication problems often stem from an information lag—material is duplicated or kept hidden to be a surprise. An effective means of internal or interplant communication would be a closed-circuit radio system or TV using 2-way viewing. This could also be applied when distributing info outside the plant—physicians and surgeons now use closed-circuit TV to keep themselves posted on the latest happenings in their field and offer post graduate courses on FM radio. He also suggested the establishment of federal companies for gathering and sending info.

C Newlon, executive editor of

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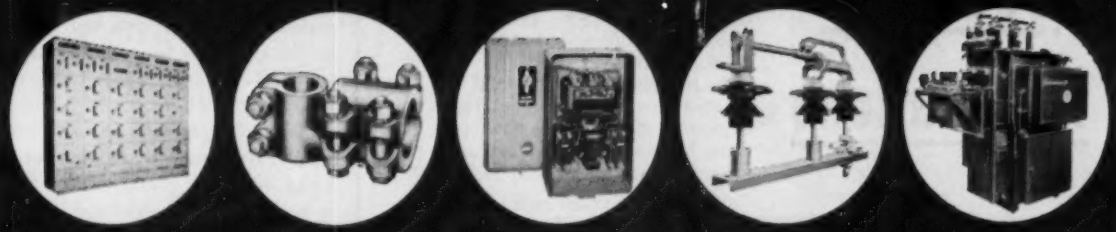

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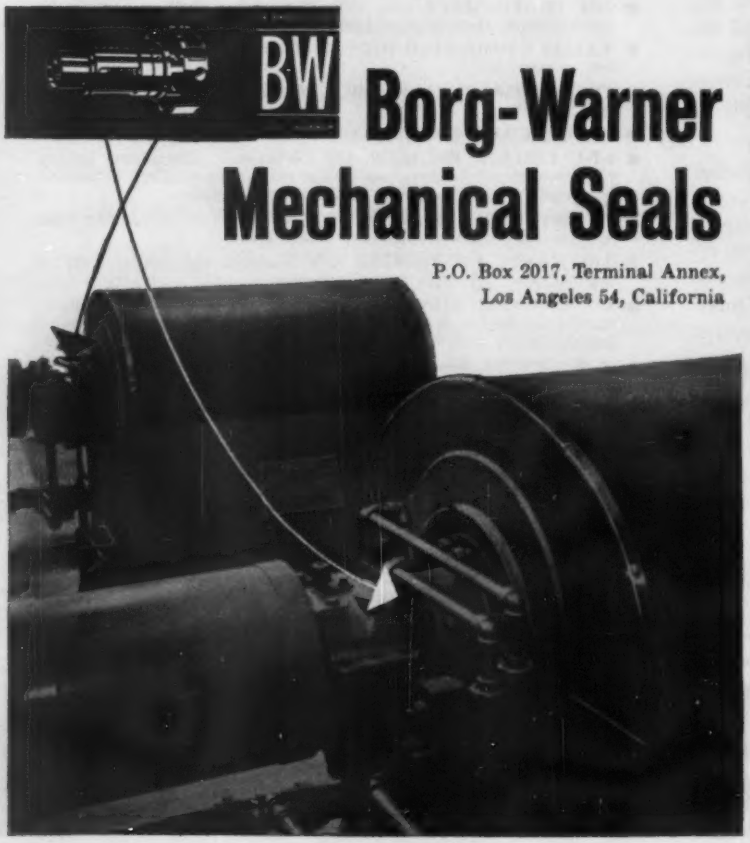

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Begins on page 180

"Missiles and Rockets" magazine, pinpointed a major problem in technical communications. A fault lies with the technician himself, he suggested. If scientific data were written in clear, simple language instead of technical "gibble gobble," everyone would be much better informed. A suggestion to the engineer and scientist writing reports in the future: begin with *Dear Mother*, check to see if mother would understand it. If she can, most of the communication battle is won.

"The Critical Million Conference was presented by New York University in cooperation with Scientific/Technological Communications, Inc.

First hyperbolic cooling tower to go in U.S. plant

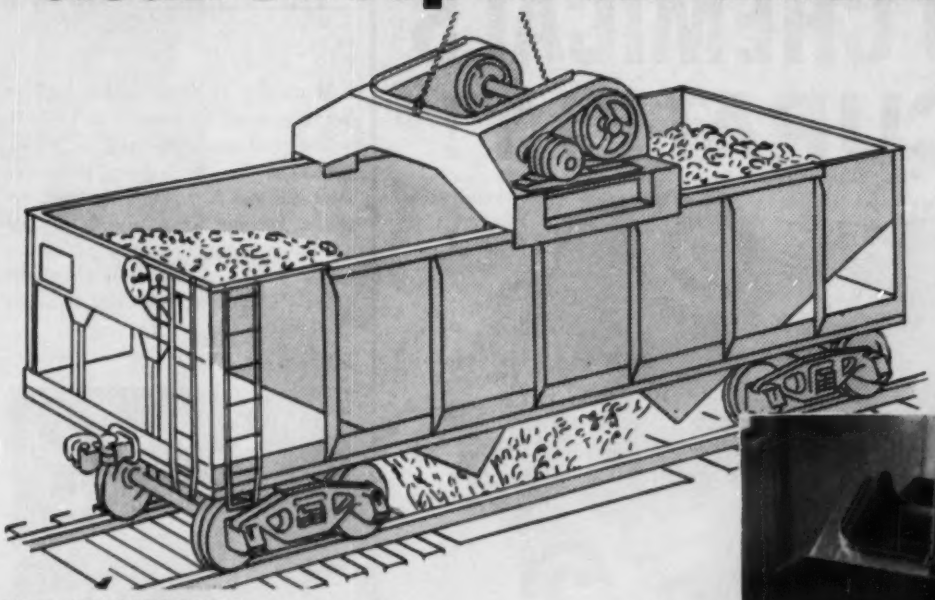
Kentucky Power Co has announced purchase of first American hyperbolic cooling tower. It will be 320-ft high — built by The Marley Co. Watch Sept POWER for up-to-date report on this new way to cool circulating water.

Reactor gains "right" side of tracks in dead of night

At 2:00 am the morning of May 1, two atomic-reactor cylinders weighing a total of 150 tons were whisked across eight lanes of the Pennsylvania Railroad's main line. Born on the wrong side of the tracks, the atomic hardware was too large to pass through customary traffic tunnels. But it had to get by to reach Baldwin - Lima - Hamilton Corp's wharf, first step in a 45-day inland-waterway and trailer trip to Hallam, Neb.

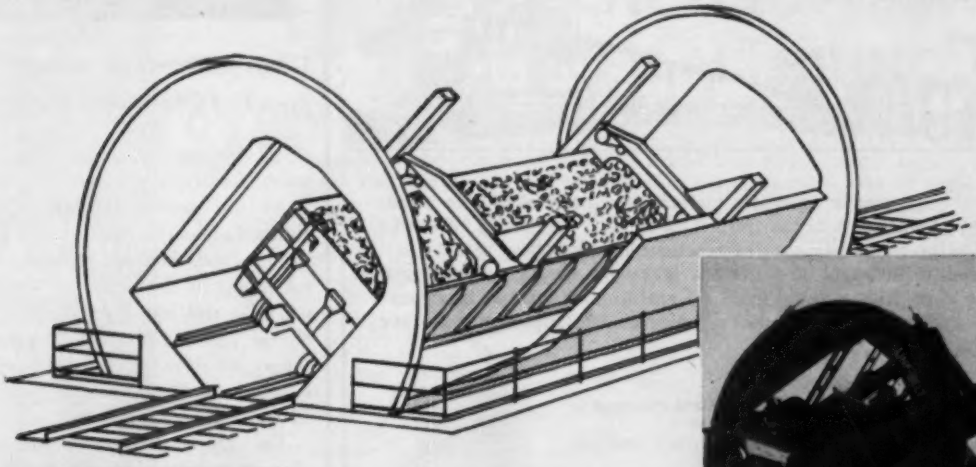
At one point company engineers considered using helicopters for sky hooks, but weight of reactor components ruled this out. Finally, engineers and PRR officials decided the cylinders could be taken across the tracks in under 15 min. So after weeks of preparation, the move was finally made—in dead of night, when traffic on the busy railroad would be at its lightest. At that, trains were

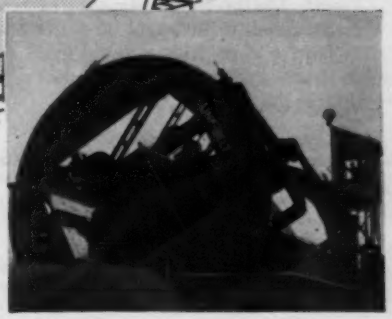
Clean sweep in car unloading!



CAR SHAKERS *(Available From Stock)*

FAIR SHAKE for coal cars. Wear to cars is no more than that encountered in normal operations over road bed. Objectionable noise can be reduced to a minimum. Shaker produces a series of hammer-like blows on the top of the car sides loosening even the hard-packed loads in minutes. Especially good for damp, sticky or frozen loads.





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You can meet any coal unloading need with equipment by Link-Belt. For large operations a Link-Belt Rotary Dumper will unload 20 or more cars per hour. For smaller plants, Link-Belt Car Shakers are available. Both are engineered to do a specific job faster . . . easier . . . at lower cost. Both reduce operational hazards and cut costly demurrage charges.

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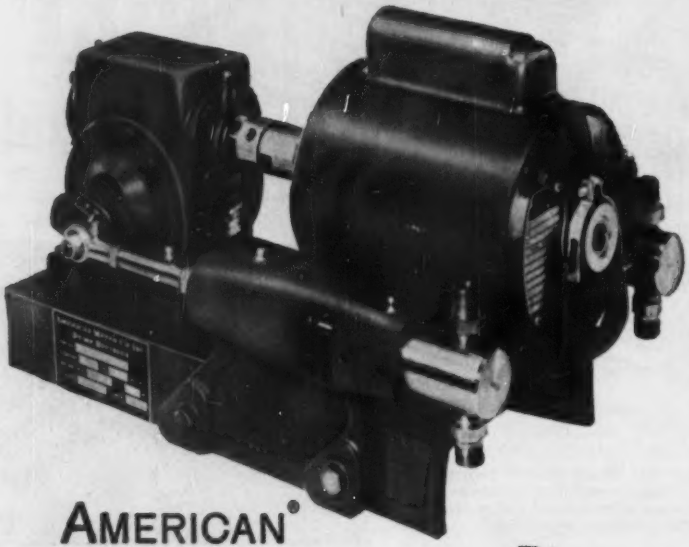

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- interchangeable liquid ends
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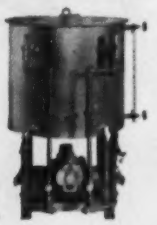

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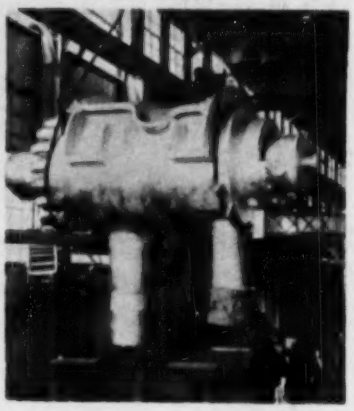
Powerscope

Begins on page 180

held up for an hour and a half so h-v lines could be shut off and raised.

The two stainless-steel cylinders, one 21-ft dia, 36-ft long, the other 19-ft dia and 33-ft long, will nest together, become the main structure for a civilian atomic power plant to be operated by Nebraska Power Authority. Each cylinder is valued at about $250,000.



Giant boiler-feed pump goes to Ohio Power Company

A 22,000-bhp pump handling 7200 gal of feedwater per min will service a 450-mw generating unit at Ohio Power Company's Philip Sporn Plant in late 1960. Believed to be the largest pump in the world in terms of capacity and hp, it operates at discharge pressure above 4500 psi. It's the second of two identical units built by Ingersoll-Rand for the American Electric Power Company.

The 42-ton pump measures more than 14 ft from outboard bearing to coupling, stands 7-ft high from bedplate bottom to top of barrel and has a rated suction pressure of 485 psig, operating temperature of 427 F. Before being shipped to the power station it underwent a rigorous test program at Ingersoll-Rand's test facility.

This concept of a single full-capacity boiler-feed pump is a design innovation for the Philip Sporn Plant. Formerly three 2000-bhp pumps handling 1100 gpm at 2385 psig serviced each generating unit. Two pumps teamed to handle full load while the third served as standby.

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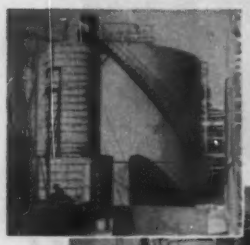

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Calendar

August 9-12 — American Institute of Electrical Engineers, Pacific General Meeting, El Cortez Hotel, San Diego, Calif. Details: H R Hughes, 1109 Alexandria Dr, San Diego 7, Calif.

August 14-17—American Society of Mechanical Engineers and American Institute of Chemical Engineers, Heat Transfer Conference and Exhibit, Statler Hilton Hotel, Buffalo, N. Y. Details: L S Dennegar, 29 W 39th St, New York 18, N.Y.

Sept 7-9—American Society of Mechanical Engineers, Automatic Control Conference and Exhibit, Mass. Institute of Technology, Cambridge, Mass. Details: L S Dennegar, ASME, 29 W 39th St, New York 18, N. Y.

Sept 7-15 — 2nd International Coliseum Machinery Show, Coliseum, Chicago, Ill. Details: A B Perkins, 2307 Sunset Blvd, Los Angeles 26, Calif.

Sept 11-16 — Illuminating Engineering Society, National Technical Conference, Penn Sheraton Hotel, Pittsburgh, Pa. Details: A D Hinckley, IES, 1860 Broadway, New York 23, N. Y.

Sept 11-16—American Chemical Society, National Meeting, Statler Hilton Hotel, New York, N. Y. Details: R Avery, American Chemical Society, 2 Park Ave, New York 16, N. Y.

Sept 14-17 — 2nd Southeastern Annual Maintenance and Engineering Show, sponsored by AIPE, Maintenance Council, AWS, State Fair Arena, Raleigh, N. C. Details: J Harden, P.O. Box 3173, Greensboro, N. C.

Sept 15-16—American Society of Mechanical Engineers, Engineering Management Conference, Morrison Hotel, Chicago, Ill. Details: ASME, 29 W 39th St, New York 18, N. Y.

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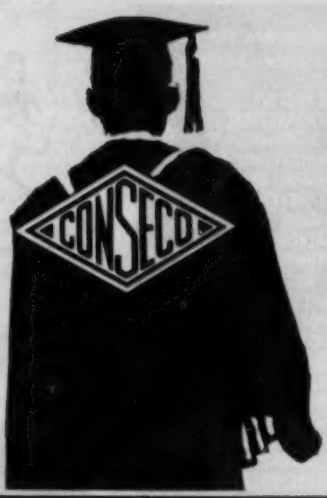

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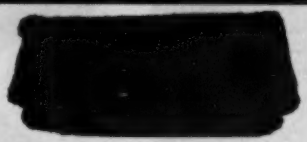

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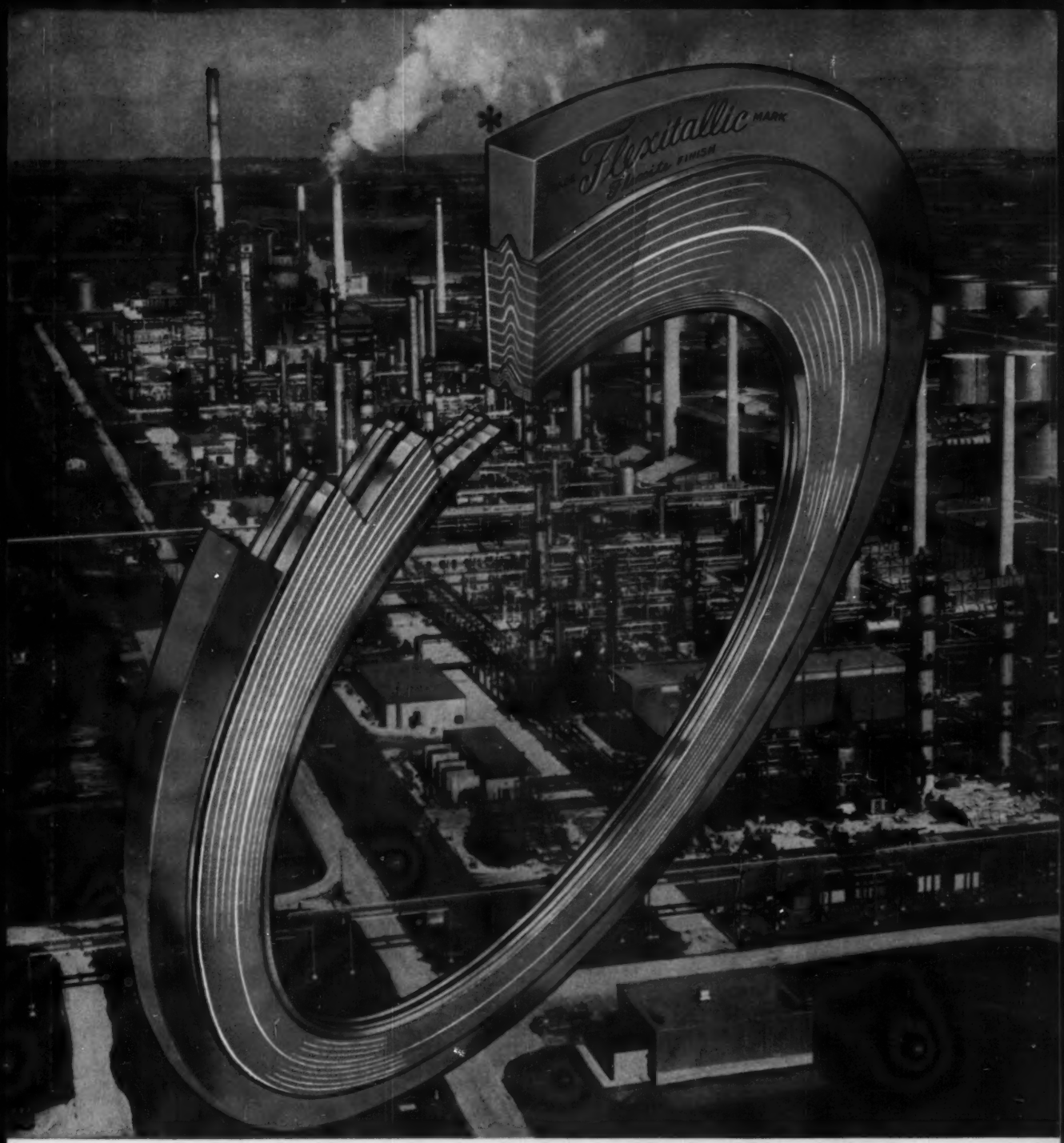


End corrosion in gasket inventory

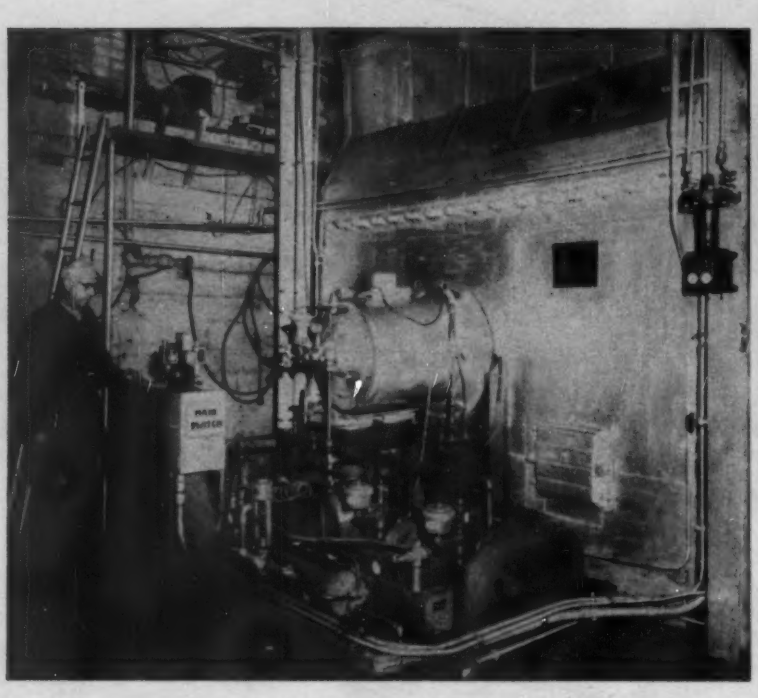
The gold Flexite Finish* for the metal gauge rings in Flexitallic Compression-Gauge Gaskets is new. It is highly corrosion resistant when exposed to severest weathering in open construction projects or in stock. The Flexite Finish provides for ease of identification and a clean, long-lived installation. Write for samples.

FLEXITALLIC GASKET CO., 8th & Bailey Sts., Camden 2, N. J.
Representatives in Principal Cities

TRADE Flexitallic MARK
SPIRAL-WOUND GASKETS
WITH Flexite FINISH

*The gold Flexite Finish is a development of the Flexitallic Gasket Co. (Originators of Spiral Wound Construction) — Register applied for on both name and color. Flexitallic Blue is our exclusive blue-dyed Canadian asbestos filler. Look for the blue and gold color combination as the mark of Flexitallic quality.

For more facts circle 324 on Reader Service card, p. 119



No Fuel Burning System Can Match O & S for Efficiency

Superiority of O&S burner systems can be demonstrated by these facts:

1. **Extraordinary Fuel Savings**—Impressive fuel savings are provided at *all* firing rates. Savings often pay for investment in a matter of months.
2. **Efficiency**—Higher *guaranteed* burner efficiency over a *wider* turndown rate than any other burner system.
3. **Performance**—O&S burner systems outperform all other assemblies. 5 to 1 turndown *without increase in excess air ratio is* widest in industry. Combustion air, accurately controlled, plays *no* part in atomization.
4. **Dependability**—No moving parts exposed to high temperatures. No tiny orifices to clog or distort.
5. **Flexibility**—Complete units for any commercial grade of fuel oil, any commercial gas (including sewer gas.) Air atomizing or steam atomizing.
6. **Typical Results**—A major New York State manufacturer is effecting a labor saving at the rate of $40,000 annually. (Name on request.)

Want more proof? We have an impressive array of case histories and performance data that are eye-openers. You owe it to yourself to investigate this outstanding burner system. Write for Bulletin 1255.

ORR & SEMBOWER, INC.

World Leader in Packaged Boilers and Burners

850 Morgantown Road, Reading, Pa. • Since 1885

For more facts circle 325 on Reader Service card, p. 119

Calendar

Begins on page 188

Sept 21-23—Power Conference, sponsored by ASME, AIEE, Bellevue-Stratford Hotel, Philadelphia, Pa. Details: ASME, 29 W 39th St, New York 18, N. Y.

Sept 25-28—American Institute of Chemical Engineers, Meeting, Mayo Hotel, Tulsa, Okla. Details: AIChE, 25 W 45th St, New York 36, N. Y.

Sept 26-30—Instrument Society of America, 3rd Instrument-Automation Conference and Exhibit, 15th Annual Meeting, Coliseum, New York, N. Y. Details: ISA, 313 Sixth Ave, Pittsburgh 22, Pa.

Sept 27-30—Association of Iron and Steel Engineers, Iron and Steel Exposition, Cleveland Public Auditorium, Cleveland, Ohio. Details: AISE, 1010 Empire Building, Pittsburgh 22, Pa.

Oct 2-5—Society of Petroleum Engineers, Fall Meeting, City Auditorium, Denver, Colo. Details: AIME, 29 W 39th St, New York 18, N. Y.

Oct 5-7 — American Institute of Mining, Metallurgical and Petroleum Engineers, Rocky Mt Minerals Conference, Newhouse Hotel, Salt Lake City, Utah. Details: AIME, 29 W 39th St, New York 18, N. Y.

Oct 6-7—National Association of Corrosion Engineers, Annual Western Region Conference, Sheraton-Palace Hotel, San Francisco, Calif. Details: T J Hull, 1061 M&M Building, Houston 2, Texas.

". . . and, they're splashproof . . ."

circle 326 on Reader Service card, p. 119 ➤

Unlike conventional electrical or pneumatic valves, new electro-hydraulically operated Hydramotors remain in last position when power is removed—until energized to trip. Designed by General Controls for use on the main gas and oil fuel lines of power plants, these Hydramotors are especially built and internally wired to close tightly in just one second—*but only on operator command.*

This eliminates the possibility of shutdown in case of power source failure...keeps flow to boilers constant at all times because these valves are electrically operated. No air pressure or pneumatic piping is required.

BE QUALITY SURE...ALWAYS SPECIFY GENERAL CONTROLS

GENERAL CONTROLS

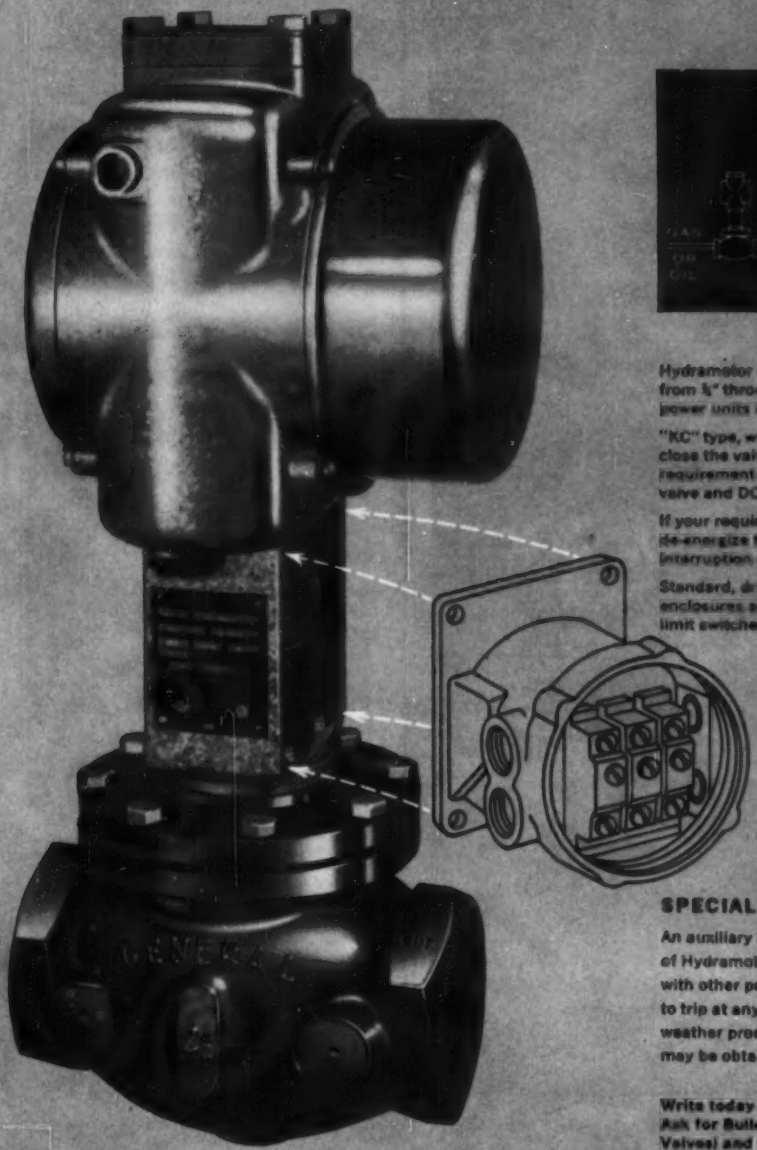
Automatic Controls for Product or Process

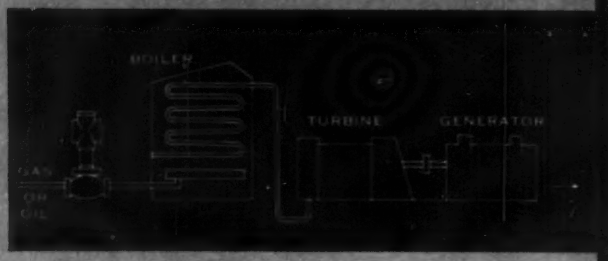
Glendale, Calif. • Skokie, Ill. • Guelph, Ontario, Canada

Nine Plants—44 Factory Branch Offices Serving The United States, Canada and Western Europe

For continuous fuel flow and instant shutoff —just say "when" to these new **HYDRAMOTOR®**

VALVES FOR POWER PLANTS





Hydramotor fuel shutoff valves are designed for pipe sizes from ¾" through 12" and are available with hermetically sealed power units in a choice of two types of actuators.

"KC" type, with simple 3-wire circuitry, uses AC power to open and close the valve. "KA" type, with 4-wire circuitry, meets the requirement of standby power by using AC power to open the valve and DC voltage to close it in case of emergency.

If your requirements are for standard Hydramotors which de-energize to trip either full closed or full open on interruption of power, these are also available.

Standard, drip proof, explosion proof and weather proof enclosures are available. Accessories include dust shields, limit switches, potentiometers and manual opening device.

SPECIAL SWITCH UNIT AVAILABLE

An auxiliary switch unit, with three switches that are independent of Hydramotor controls, is available to interlock the shutoff valve with other power plant systems. Each switch is adjustable to trip at any position of valve stroke. This explosion proof, weather proof unit can be mounted in the field. Six SPDT switches may be obtained by using two of the units with a Hydramotor.

Write today for specifications and complete information. Ask for Bulletin SD1-H2, 3KA, C-1 (Hydramotor Shutoff Valves) and Bulletin 608.287 (Auxiliary Switch Unit).

ANTI-PARALLAX FACE
Anti-parallax BIMET® face eliminates reading errors when dial is viewed from any angle.
STAINLESS STEEL CASE
Stainless Steel Construction throughout, including the most rugged Polished Stainless Steel Case available for the ultimate in corrosion resistance and strength, is exclusively provided on all Moeller BIMETS.
Moeller Features
HERMETICALLY SEALED
Hermetically sealed with dry air to prevent entry of moisture and condensation throughout the life of the instrument.
RECALIBRATION
Exclusive Moeller external recalibration feature provides adjustment of pointer on scale so that scale is always upright and easily readable. Thermometer remains sealed. Only Moeller BIMETS offer the convenience and error-free readability of vertically oriented dials.
Provide Timeless Accuracy
You'll appreciate the superior accuracy, reliability and rugged construction of the NEW 3" and 5" BIMET® Thermometers. Silicon dampening stabilizes the pointer against vibration assuring precise reading and reduced wear.
Moeller BIMETS offer superior reliability of measurement, easy, accurate reading, the most rugged construction, simplicity of installation and guaranteed accuracy of 1% of full scale.
The NEW 3" and 5" BIMETS are available for ranges from −100 F to +1000 F or −70 C to +500 C with glass or plastic fronts. Standard ¼" or ⅜" O.D. stems, up to 100" in length may be ordered in any angular position. Moeller exclusive swivel nuts or fixed connections are furnished.
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Appointments

John Bertram Adams

CERN (European Organization for Nuclear Research) will be directed by John Bertram Adams, at present director of their Proton Synchrotron Div, until the latter part of this year. He will fill the post of interim director-general of the organization—an appointment necessitated by the recent death of Prof C J Bakker, former director-general. Adams was recently appointed director of the new Controlled Thermonuclear Research Establishment in the United Kingdom, a post he will fill when he leaves CERN.

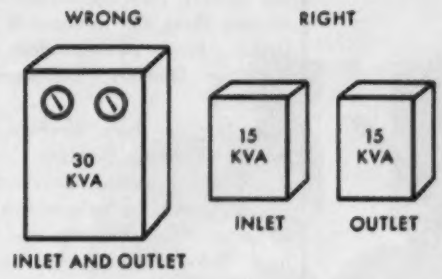
Since 1954 Adams has led the team which built the world's most powerful particle accelerator. Up to that time he worked with the Ministry of Supply in Britain. He helped design and construct a 110-in. synchrocyclotron while at the Atomic Energy Research Establishment in Harwell. This 175-mev machine was the first high-energy proton accelerator built after the war—it has been operating without interruption since 1949. Adams also developed high-frequency klystrons with 20-mw pulsed output to power linear accelerators.

Arthur J Benline

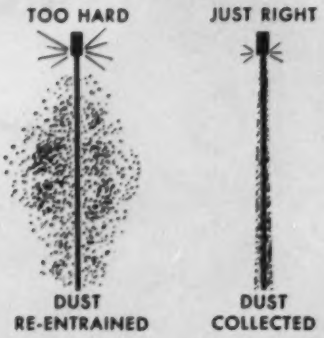
Air Pollution Control Department of New York City will be headed by Arthur J Benline. He was recently appointed commissioner of the department by Mayor Robert Wagner.

Commissioner Benline, a professional engineer and registered architect, is well known for his work in

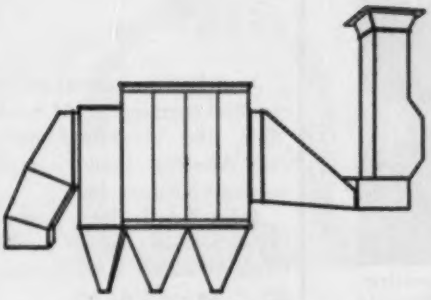
How to Evaluate Cottrell Precipitators



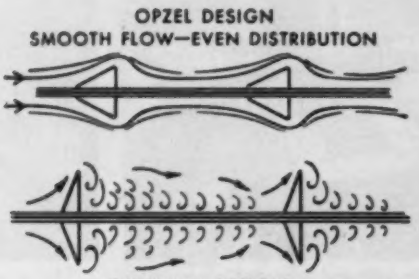
1. Electrical Sets should be arranged and rated to suit best the requirements of a specific job. Since electrical conditions can vary widely at different parts of the precipitator, it is good design to include several electrical sections in series, energized from separate sets so that each section may be energized as needed. Sets should be sized according to the amount of power the precipitator can absorb. A large excess of installed power, which will never be absorbed, means inefficient use of its equipment.



3. Rapping Intensity. Rappers should have easy means to vary the intensity of the blow to suit variations in operating conditions. A pre-set intensity setting cannot possibly give proper rapping over the normal range of operation. If too soft, build-up will occur which will disturb electrical conditions. If too hard, there will be reentrainment. Means of intensity adjustment are necessary to avoid drop-off of precipitator efficiency as conditions change.


3 DIMENSION MODEL

2. Gas Distribution. Remember that gas distribution, gas baffling, and provision against hopper sweeping all have a large influence on collection efficiency. The gas flow system should be analyzed as closely as possible, both in the precipitator and in the associated duct-work. If in doubt, have a three-dimensional gas flow study made. Two-dimensional gas flow studies *are not as accurate* and may lead to erroneous conclusions.



4. Baffle Design. Careful attention to the design of baffles on the collecting plates is most important. Small amounts of reentrainment mean tremendous differences in over-all collection efficiencies. It is seen that the "quality" of the collecting surface is far more important than quantity—quantity (sq. ft. of surface or treatment time) in itself is not a criterion of performance.

The point of all this is that so many factors enter into evaluating an electrical precipitator that you should consult with the leading manufacturer—Research-Cottrell

Research-Cottrell, with over 1198 years of combined engineering skill and experience, is the undisputed leader in electrical precipitation.

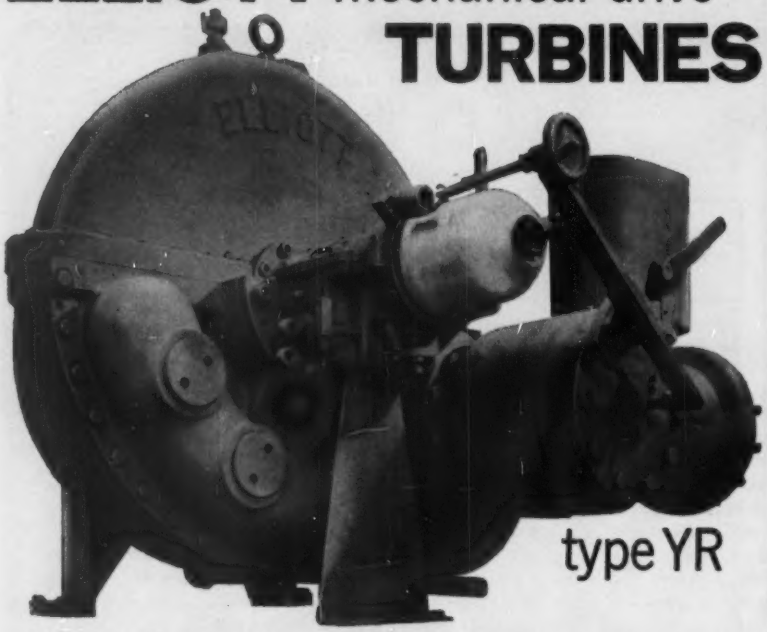
Research-Cottrell

RESEARCH-COTTRELL, INC., Main Office and Plant: Bound Brook, N. J.
Representatives in principal cities of U.S. and Canada

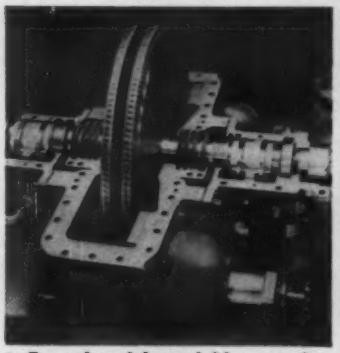
COTTRELL TRADE MARK

RC 804

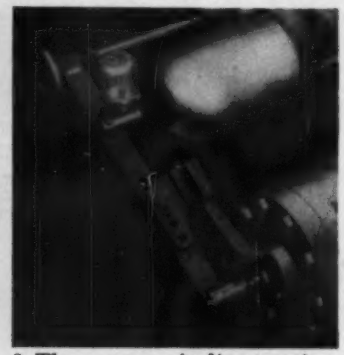
ELLIOTT mechanical drive TURBINES



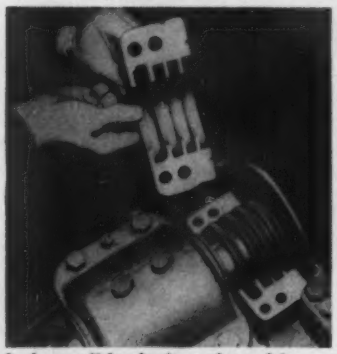
These features mean long life, easy operation



1. Smooth and dependable operation at all operating temperatures is assured by the precise alignment of the dynamically balanced shaft.



2. The governor is direct-acting, simple and weather-proof. Separate trip gives over-speed protection. Easily reset against line pressure.



3. Accessible shaft-seals and bearings simplify maintenance and inspection. Covers are readily removable without disturbing the casing.

4. Economy at partial loads is secured by the steam-saving hand valve with pilot, which can be opened against full steam pressure.

ELLIOTT Company
JEANNETTE, PENNA.

HO-2

Appointments

Begins on page 192

drafting, administering and enforcing modern building regulations including those for mechanical installations. He is past-president of the Building Officials Conference of America.

Benline has been director of the New York State Building Construction Code since 1952. Before that he was Manhattan Superintendent of the Department of Housings and Buildings. Before entering public service, he directed construction and installation of mechanical equipment in large theatres, commercial buildings and major oil-distribution facilities.

During World War II Benline commanded a Seabee battalion and amphibious task groups, seeing naval-construction duty in the Mediterranean, fleet operations throughout the Pacific and combat-assault landings in Okinawa. He is now Captain in the Civil Engineers Corps, U.S. Naval Reserve. He is a graduate of New York University.

Awards

Neal R Amundson, professor of chemical engineering at University of Minn., the American Chemical Society Award in Industrial and Engineering Chemistry.

John Boyd, Bearing and Lubrication Section manager for Westinghouse Research Laboratories, 1960 ASLE National Award.

Morris Cohen, head of corrosion lab at Applied Chemistry Div, Canadian National Research Council, 1959 Whitney Award from NACE.

James F Fairman, senior vice-president of Consolidated Edison Co, AIEE Edison Medal.

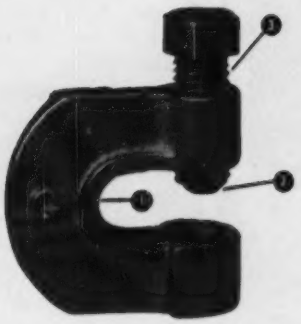
J C Hudson, corrosion engineer with British Iron and Steel Research Association, England, Speller Award from NACE.

Dr Augustus B Kinzel, vice-president of research, Union Carbide Corp, AIME James Douglas Gold Award.

Dr Dean A Lyon, scientist and consulting engineer, AIEE John Scott Medal.

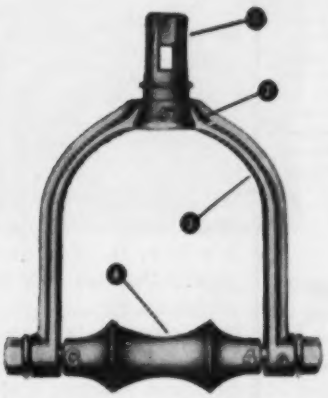
Robert Franklin Mehl, head of Metallurgical Engineering Dept, Carnegie Institute of Technology, Institute of Metals Medal for 1960.

Look at all the extras you get in Grinnell Pipe Hangers . . . yet you pay no more!



GRINNELL C-CLAMP, FIG. 88 — 1 Ribbed, malleable iron casting, for extra strength **2** Hardened steel, cup-point set screw for good "grip" on beam **3** Full thread engagement – casting is drilled and tapped for rod and set screw

GRINNELL EXTENSION SPLIT RING, FIG. 138 — 1 Nipple engaging thick section of malleable iron gives rigidity for support from above, below or from wall **2** Tapped to take screw. No nut to lose **3** Special ring contour holds pipe or tubing firmly



GRINNELL ADJUSTABLE SWIVEL PIPE ROLL, FIG. 174 — 1 Swivel shank permits adjustment without elaborate support **2** Locking device prevents accidental adjustment change; no lock nut required **3** Ribbed design in malleable iron for better strength, lightness, appearance **4** Easy installation; maximum adjustment

GRINNELL CB CONCRETE INSERT, FIG. 282 — 1 One body size accommodates several sizes of rods **2** Slot takes reinforcing rods to assure maximum load rating **3** One-piece body prevents concrete seepage **4** Teeth on insert and nut hold rod firmly in place **5** Homogeneous composition of malleable iron throughout

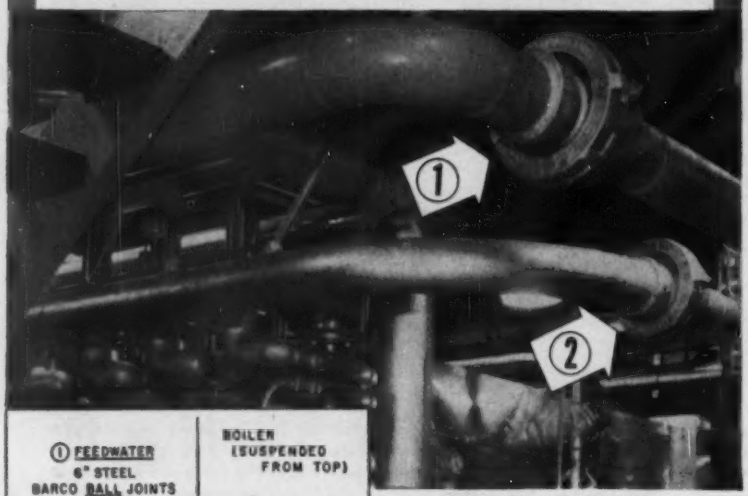
You get *more* hanger for the money from Grinnell, because Grinnell's huge volume reduces production costs . . . lowers prices right into line with competitive hangers offering less.

Yet you get *so much more* . . . wider choice of types and sizes; better quality control; published ratings for *all* hangers; faster delivery from warehouses nationwide; and more responsible field service by trained Grinnell personnel . . . regardless of how far from the job site the sale was made! Grinnell Company, 277 West Exchange St., Providence 1, R. I. Branch Warehouses in Principal Cities.

Remember, The Best Costs No More — from America's #1 Supplier of Pipe Hangers and Supports

Call your local Grinnell Distributor for pipe hangers, cast and malleable iron fittings, malleable unions, steel nipples – all made by GRINNELL

. . . where BOILERS move UP and DOWN



Handle THERMAL EXPANSION with BARCO Ball Joints

The schematic diagram at left shows how Barco Flexible Ball Joints of steel construction are used in a new Florida utility plant—design pressure 600 psi, 500°F. The above photo shows a close-up view of two of the joints (see arrows). Two more matching joints, 4" and 6", are located out of the picture to the left. The 4" joints have metal gaskets. The same utility also uses 10" Barco joints on gas fuel lines. Other uses in power plants are for flexible connecting lines to oil burners, soot blowers, and other auxiliary equipment.

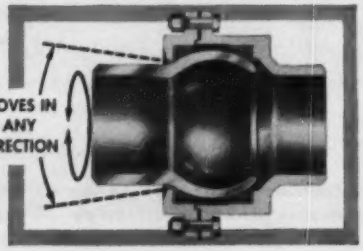
BARCO

Solves Piping Problems!

The rapidly increasing use of Barco Flexible Ball Joints for solving piping problems in POWER PLANTS is significant for several key reasons:

1. Substantial *space saving* as compared to other methods in crowded piping areas.
2. Unlimited flexibility and movement. Utmost simplicity.
3. No heavy pipe anchoring required. No "end thrust" developed under pressure.
4. Ability to handle compound movement (where twisting is combined with thermal expansion and contraction).
5. Easy to engineer joints into piping to provide for any degree of flexibility, expansion, or movement required.
6. Maximum safety for high temperature applications. All-metal construction available. Special alloys can be specified.
7. Basic design is pressure sealing against leakage and self-adjusting for wear.
8. Virtually no deterioration. Able to stay in service for years without repairs or maintenance. No lubrication.

New Bulletin No. 31 contains interesting diagrams showing how to solve many common pipe expansion problems EASILY, ECONOMICALLY. *Ask for a copy;* see your nearest Barco representative or write:



BARCO MANUFACTURING CO.
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Bookshelf

Electrical Efficiency in Industrial Plants. *By E S Lincoln. 235 pp, 6 x 9, $9.50. F W Dodge Corp, 119 W 40th St, New York 18, N. Y.*

Written by veteran electrical consultant, book attacks problems of reducing electric-power and lighting costs in industrial plants. It outlines practical methods any engineer or supervisor could use in cutting waste and misuse of electric power.

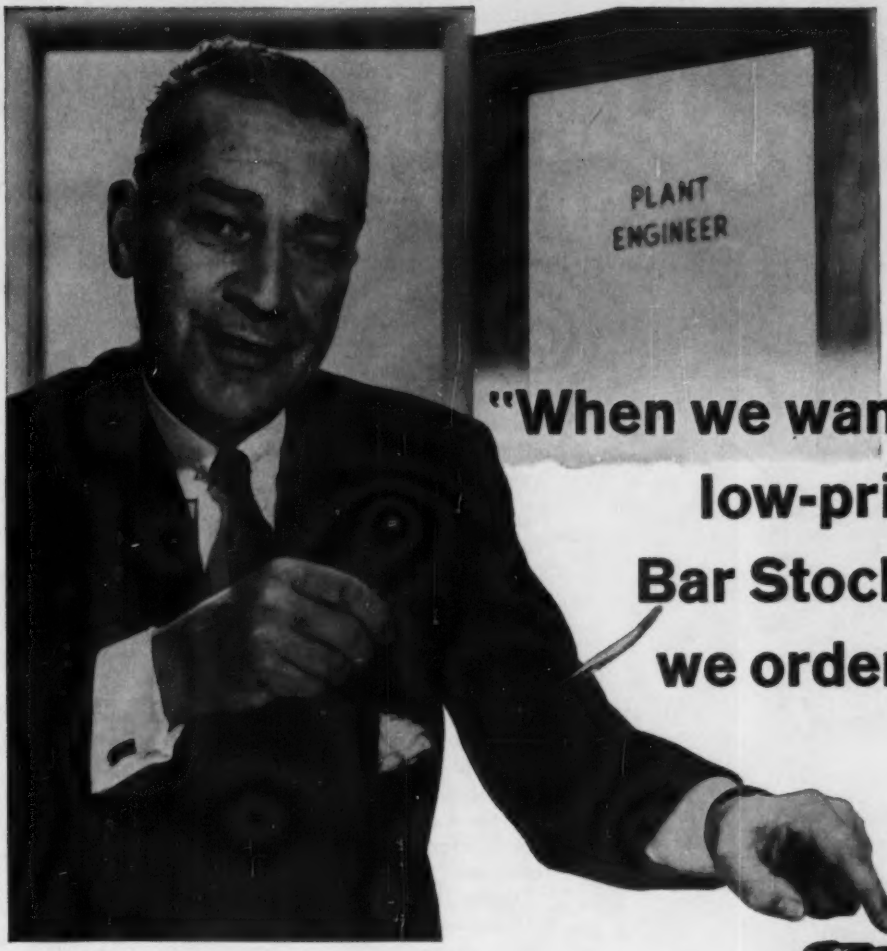
Author points out that although this drain is small within a given period, profit loss is compounded with time and becomes more serious when new equipment and loads are added. He suggests how to survey load, power factor, voltage, lighting, wiring and electric protection. Included is an analysis of power costs showing methods of lowering rates by minimizing peak demands.

Book is supplemented with illustrations, diagrams, tables and check lists. Valuable addition is series of case studies from author's records.

Atmospheric Sampling and Analysis, D-22. *112 pp, hard cover, 6 x 9, $2.25. American Society of Testing Materials, 1916 Race St, Philadelphia 3, Pa.*

Book compiles 12 standards, nine methods of test on atmospheric sampling and analysis. Purpose is to fill need for standardized sampling procedures, analytical methods, definitions of air resources. Contents list includes: methods for continuous analysis and automatic recording sulfur-dioxide content of atmosphere, test for concentration of odorous vapors, definition of terms relating to atmospheric sampling and analysis, test for inorganic fluoride in atmosphere, test for oxides of nitrogen in gaseous combustion products—phenol-disulfonic-acid procedure, test for odor in industrial water and industrial waste water, test for particles in the atmosphere (optical density of filtered deposit) and many others.

Generating capability of U. S. electric-power industry will reach 170.5-million kw by end of '60, according to Edison Electric Power Survey.



"When we want rugged, low-priced Bar Stock Valves we order R-P&C"

"For a really versatile, **all-purpose** valve, we've found there's none better than R-P&C bar stock valves. Designed and built **for close control service,** the construction of these valves makes them well suited to many general purpose applications as well. For example, the **compactness** of R-P&C bar stock valves is particularly advantageous for close-coupled installations in instrument lines or on panel boards and for pressures up to 10,000 lbs. in steel."

These valves are available in a wide variety of materials to withstand extremely high temperatures and pressures. But best of all, R-P&C bar stock valves are economically priced. This is made possible through special techniques developed by R-P&C.

We highly recommend R-P&C bar stock valves for meter, gauge, sampling, or test valves on equipment requiring a reliable compact valve that can withstand high pressure service.

Contact your R-P&C distributor for full details about bar stock valves in bronze, carbon and stainless steels plus the complete line of R-P&C gate, globe and angle valves in all standard materials.

R-P&C VALVES

ACCO

R-P&C Valve Division, American Chain & Cable Company, Inc.

Reading, Pa., Atlanta, Boston, Chicago, Denver, Detroit, Houston, New York, Philadelphia, Pittsburgh, San Francisco, Bridgeport, Conn.

For more facts circle 332 on Reader Service card, p. 119

George Edwards

unearths a nugget of history

In downtown New York a few months ago, I stopped into an automat for a quick cup of coffee and a piece of pie. Grabbing the nearest empty seat, I found myself opposite a little old man who could have passed for the twin brother of Happy of Seven Dwarfs fame. Nodding pleasantly to me, he waved his fork toward another table where a man was eating half a cantaloupe.

"Fifteen years in America I've been;" he beamed, "still I can't see how you can eat such shtuff. In Johannesburg we're giving them to the pigs—even they don't like them."

I agreed that man is a creature of varied tastes, and with that our conversation was off and running. He was obviously lonely and wanted to talk. A plain, almost pathetic-looking little guy to be sure, but I'm glad I stayed through four cups of coffee to listen to his tale.

Born in Belorussia, he was taken to South Africa at five by a horny-handed farmer father whose only wish was to till land he could call his own. When the boy finished the equivalent of our high school, he decided that farming wasn't for him and took off for the big city. In Pretoria he worked at one job, then another, finally wound up as clerk in a whiskey-by-the-case shop. The Boer War was in full swing at the time and the clerk was more than mildly astonished one afternoon to see a young man, very obviously British and quite self-assured, stroll into the shop. He wore a nondescript cap, a British Army officer's blouse and a pair of civilian trousers. Tapping impatiently on the counter with a swagger stick he was carrying, he snapped, "Young man, do you have so-and-so brandy?", naming a most expensive bottle.

"Y-yessir," stammered our clerk, while such thoughts as "has Pretoria been taken?" and "he must be a British spy" tumbled through his mind.

"Well, let me have two cases and be quick about it," said the stranger. Numb with confusion, the clerk quickly brought the two cases and set them on the counter. The Englishman pulled a checkbook from his pocket. "I've less than a pound with me," he said, "so I'll have to give you this." Signing the check with a flourish, he handed it to the unresisting clerk, then added, as he wrote something on another piece of paper, "have the brandy delivered to this address."

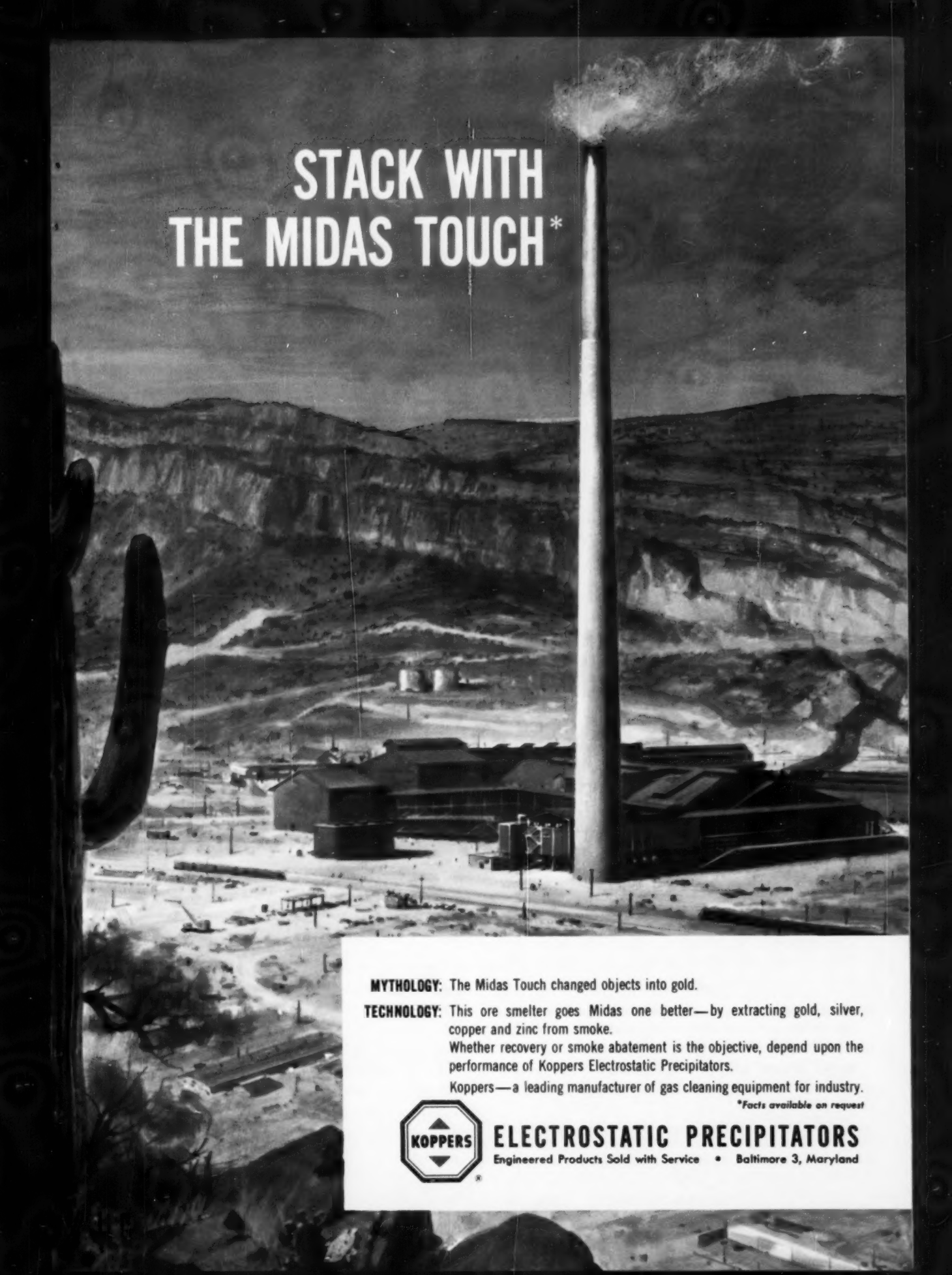
As the man wrote, the clerk looked at the signature on the check—and felt as though someone had hit him on the head with a mallet. Big as life and in a bold hand was written *Winston S Churchill.*

The clerk gulped. Everyone in South Africa had heard of the intrepid Churchill's capture. "But—aren't you supposed to be our prisoner—or something?" he asked meekly. The Churchill jaw jutted. "Young man," he rasped, "you tend to your whiskey selling and I'll tend to my affairs," and turning on his heel he walked casually into the street.

The old gentleman chuckled repeatedly as he recalled the incident. Later, he said, he got into the theatrical-agency business and eventually met Churchill's actress daughter Sarah just after World War II. He told her the story and she laughingly suggested that he write to her father and see if he remembered. The old gentleman did so. About a month later he got a short note from the Prime Minister: "Never heard of you, you bounder. Incidentally, I hope you are feeling fit."

I hope you'll enjoy the story as much as I did. It's something that we'll probably never see in Churchillian memorabilia. I can't vouch for its authenticity, but I believe it. Above all, it demonstrates what rich experiences we can miss if we're not willing to sit back and listen once in a while.

circle 333 on Reader Service card, p 119 ➤



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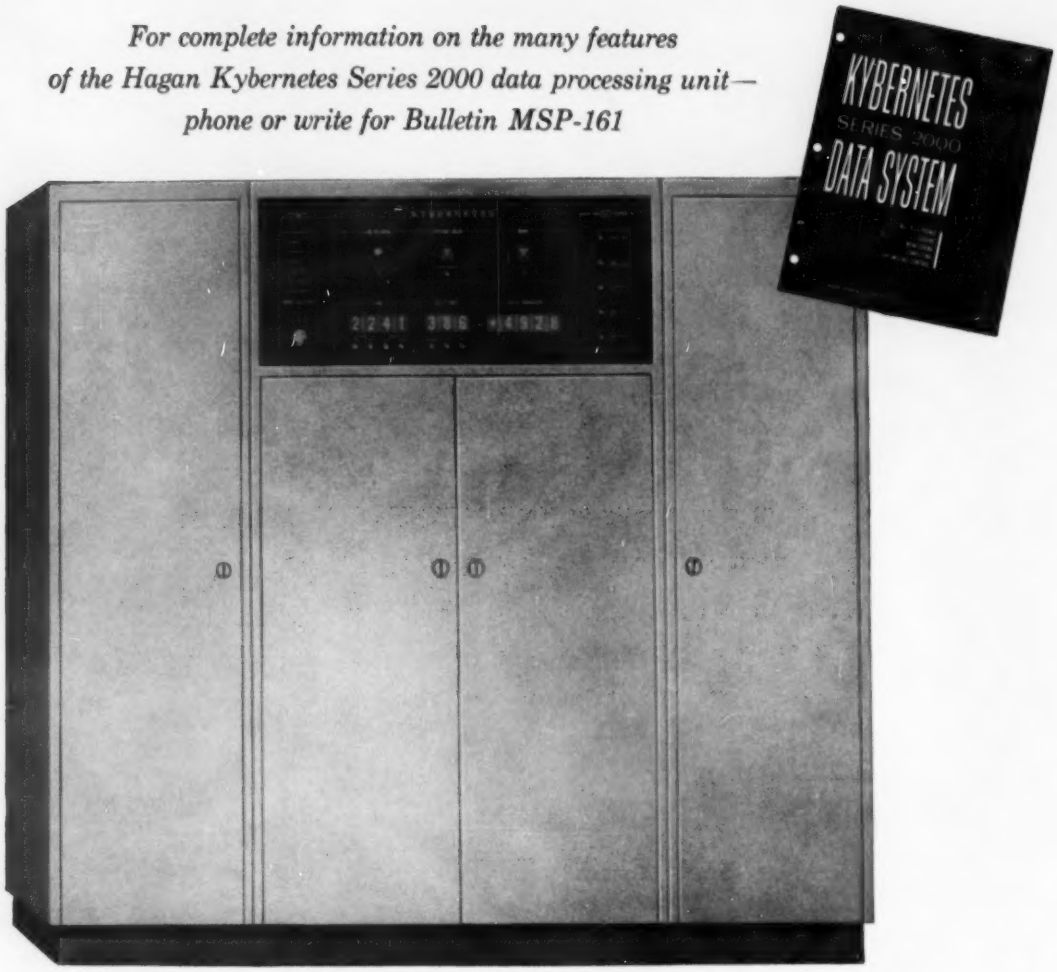

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HIGH ACCURACY—Simplified design and highest quality components provide an overall accuracy of ±0.1% of full scale.

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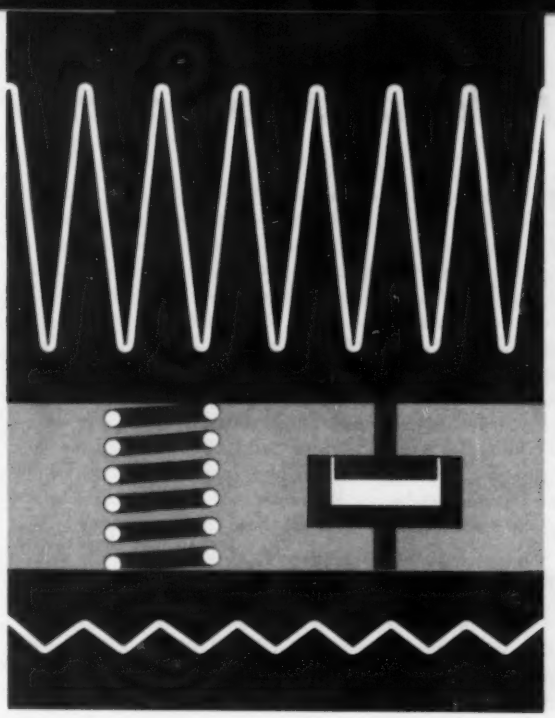
VIBRATION ISOLATION



By STEVE ELONKA, Associate Editor

Today, isolators are, in a way, turning large industrial and office buildings upside down. How? For years heavy machines were installed on the ground floor, firmly bolted down to concrete foundations. Or if they had to be installed on upper floors, building structure became massive to withstand shock and vibration produced by the running equipment. Even then, noise and vibration throughout the building were often a nightmare.

But now architects install heavy air-conditioning machinery, large blowers and even steam generators and diesel engines wherever they please—even in the penthouse. They design lighter supporting structures because they first *isolate* shock and vibration. Building design and plant layout are improved, and multiple fringe benefits include lower machinery- and building-maintenance costs, longer bearing life and decreased annoyance and distraction for workers in vicinity of vibrating equipment.

What is vibration? It is energy diverted from a useful purpose to a destructive end. That makes it a high-ranking public enemy to the energy-systems engineer, one of his most costly headaches. Of course, equipment balancing to cut vibration is the first step, but the best balancing seldom hits perfection. You can expect that some harmful forces will remain, enough to add up to a complete knockout blow unless they're properly handled.

Yet isolating or damping these destructive forces can be surprisingly inexpensive. Consider all forms of isolation; they're highly efficient ways to save building and maintenance dollars, stretch service life of your equipment and bypass some very literal headaches. In the following 15 pages we will give you the information you need on vibration causes, cures and the ever-expanding lines of hardware available to isolate it effectively.

NOTE: This is Part 2 of a 3-part handbook on vibration and noise. Part 1, *Balancing Rotating Machinery*, a 24-p special report, came out in June 1959. Part 3, *Preventing and Isolating Noise*, will probably be published in 1961.

a **Power** special report
August 1960

Isolation steps in where balancing leaves off

It would be fortunate indeed if perfect balancing of rotating equipment were practical—there would be no need for concern about vibration isolation. But perfection is far off. Sure, there are norms a manufacturer shoots for in initial balancing out. And there's plenty you can do to maintain good balance for a full machine life (see *Balancing Rotating Machinery*, June 1959, a POWER special report). But what is left undone must be compensated for by isolation, preventing unavoidable vibration from being transmitted throughout system and building structure. Before tackling the problems of isolation let's review some principles behind vibration and some headaches it creates for manufacturer and plant operator. Ask yourself these three questions:

Vibration or shock?

And there is a difference. Vibration is a periodic motion which takes place when any elastic system is displaced from its equilibrium position and released. Shock, on the other hand, is a disturbance produced by a suddenly applied force. Here the oscillations die out before the next impulse. In this report we deal mainly with vibration as a continuous steady-state condition.

If vibration were confined to a single, simple motion, its control would be straightforward. Actually, some six modes of motion must be considered, both *translational* and *rotational* movement involving the basic vertical, longitudinal and lateral axes. In practice, most mounting designs are based on vertical considerations because maximum building sensitivity lies in this direction. But the other modes should also be investigated.

Internal or external?

Where prime consideration is preventing escape of vibration from a troublesome machine, you might classify the vibratory source as internal. External classification refers to vibration originating outside the machine you are immediately concerned with, that must be kept out.

As outlined in *Balancing Rotating Machinery*, there are many causes of internal vibration in rotating equipment. Typical: nonhomogeneity of materials, nonsymmetry of cast parts, distortion at operating speed, unequal mass distribution after machining. Remember, all these can be corrected to a degree by dynamic balancing. But what isn't practical to correct, isolate.

Isolating externally-caused vibration can be even more tricky. A common case of external vibration is the railroad train passing a plant where precision machining is being done. There are cases on record where railroad timetables are consulted and highly accurate work suspended while a train approaches and passes the plant.

But you don't have to have a railroad or drop hammer nearby to be troubled by external vibration sources. Many simple machines can join their vibratory forces to set up a resonant condition. This occurs when frequency of the first machine is the same as, or a multiple of, natural frequency of the second. Military example is found when soldiers on a bridge break step for fear their cadence might match bridge's natural frequency.

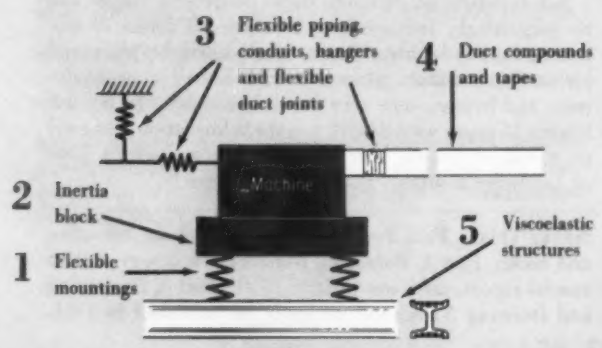
Intensity of vibration feedback depends on many things. One is condition of the soil under your plant. Reason: machine foundation supported on soil constitutes a mass-spring system with its own natural frequencies. It can oscillate in any of the six modes depending on direction and location of the applied force.

How serious a problem?

Plenty serious. Take piping systems for example. They're near-perfect conductors of vibration. For this reason a pump or compressor can be the undetected cause of a repeated valve failure at other end of the plant. Leaky and cracked joints can often be traced to external vibration. Entire piping systems have been known to fail because of uncorrected vibration straying through them.

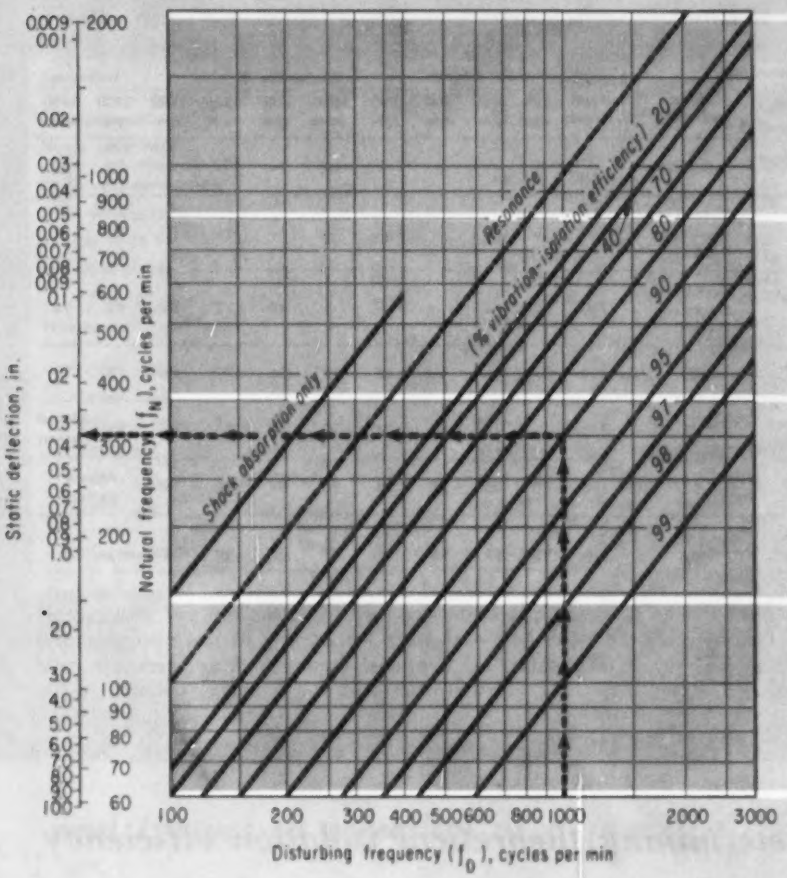
The rumble of large cookers, condensers and similar vessels, where steam discharges through nozzles into liquid, is another potential source of vibration. Such large vessels have been known to "walk" along the floor before they were properly damped and isolated. Merely bolting down is seldom the answer, since the unit will shake the entire building. This vibration damages both vessel and building if allowed to continue unchecked.

The five practical steps in isolating machine vibration



First and simplest solution to consider is placing an isolator directly under the machine; in most cases this will be satisfactory. If not, and knowing isolation efficiency you want, investigate the practicality of increasing machine mass, item 2 in sketch. Once machine is isolated from floor, look into ways of keeping vibration from translating through connected piping and ducts, items 3 and 4. Flexible connectors, spring hangers, duct wrapping come into the picture here. Finally, item 5, consider the building structure itself. All these factors are discussed in that order in the following pages.

Start here to pick most efficient, economical isolator



UP TO 1/16-IN. static deflections use cork, duck impregnated with rubber over 70-durometer hardness, rubber mounts, felt pads, lead-asbestos pads, fiber glass. Use any of the harder materials with little "give", singly or in combination, so long as deflections do not exceed 0.05 in.

UP TO 1/4-IN. static deflections use multiple layers of neoprene pads, their hardness depending on load, standard neoprene-in-shear mounts, thick felt pads or cork engineered for the specific problem. Lower area in chart takes spring mounts

UP TO 1½-IN. static deflections use steel springs. Multiple layers of rubber or neoprene pads are OK for the upper area here, but thickness must be just right. But because of large areas and volumes of materials needed, springs are most economical

UP TO 14-IN. static deflections use steel springs—only mounting to handle these deflections. Use coil or leaf springs. For low-speed equipment, up to 5-in. deflections, isolate for positive control—equipment to floor. Over 5-in. deflection, isolation is negative—transmitted floor to equipment

Consider frequency of vibration, both natural and disturbing

Before tackling this matter of isolator selection there are several important preliminaries. First, decide whether it is most practical to isolate the cause of vibration or the specific equipment being affected. Second, master the engineering principles governing vibration isolation. Third, become familiar with the various commercial isolators available and advantages and limitations of each. The first consideration involves specific equipment layout and the economics of internal and external vibration isolation. Later in this report we will cover the various devices available to do the job. So at this point let's look into the few engineering principles on which a satisfactory job depends.

Natural frequency, what it means and how it enters the overall picture, is a logical starting point. Every part of a structure, and about everything in nature, has a natural frequency of vibration. This is the frequency at which it will vibrate on receiving a shock. One example is a ball bobbing up and down on a rubber string. The ball would keep in motion indefinitely in a vacuum if it were not for energy losses caused by internal friction in the rubber.

Fortunately, as in the case of the simple pendulum where frequency is a function of length, natural frequency of a mounted machine depends on static deflection of the resilient supports independent of the mass. Formula for natural frequency, cpm: $F_n = 188\sqrt{1/d}$ where d is static deflection of resilient supports. Keep in mind this formula applies only to mountings having uniform deflection rate without excessive damping. Other mounts are more complex.

Installations weighing as much as two tons can be checked for F_n in the field by shutting down the equipment, then setting the installation in motion by jouncing on the base or using a simple lever. Number of oscillations for any given period is divided by time to arrive at the natural frequency. Example: equipment might be set in motion and 30 oscillations counted in ten seconds. The F_n is three per second or 180 cpm.

A more rigorous analysis should include the three modes in both translational and rotational motion—mentioned on the opposite page. But in most work it is satisfactory to consider the vertical frequency only. Reason is that this is the direction of greatest floor sensitivity.

Disturbing frequency, sometimes referred to as *forced frequency,* is cpm of the vibrating body at the source of the trouble. Once again this frequency may be self-induced or transmitted from a distant point, such as an air-conditioning machine up in the penthouse. Instruments for measuring frequency are shown in *Balancing Rotating Machinery,* p 220.

continued

Theoretical isolation efficiencies

Isolation material	Average static deflection	Average natural frequency	Efficiencies, % 350 rpm	500 rpm	600 rpm	800 rpm	1000 rpm	1200 rpm	1500 rpm	1800 rpm	3000 rpm	3600 rpm
2-in.-thick standard-density cork	0.08	By test, 1420	—	—	—	—	—	—	—	—	72	82
Type W waffle pad	Curvature corrected, 0.035	1000	—	—	—	—	—	—	20	55	87	92
Two layers of W waffle pad	Curvature corrected, 0.070	710	—	—	—	—	—	46	71	82	93	96
Single-deflection rubber mountings	0.20	420	—	—	—	62	79	86	91	94	98	99
Double-deflection rubber mountings	0.40	300	—	44	67	84	90	93	96	97	99	Almost perfect
Standard spring mountings	1.00	188	70	85	89	94	96	97	98	99	Almost perfect	
Double-deflection rubber & spring mountings	1.40	160	75	89	93	96	97	98	99	Almost perfect		

NARROW DOWN type of mounting and material needed to do the best job with help of this table. Not all materials are shown here—others on market may be just as efficient and economical. But you can use these values for a general guide, checking average natural frequencies as well as the theoretical isolation efficiencies for common operating speeds

Here are keys to determining theoretical isolation efficiency

Determination of the disturbing frequency can be made from the speed of the driven equipment or its driver, whichever is lower. A machine running at 400 rpm has an F_d of 400 cpm. Both F_n and F_d enter into determination of . . .

Isolation efficiency. Ability of any mounting to isolate vibration is generally expressed as a percentage and termed *isolation efficiency*. This factor can be checked in the field by measuring with vibration instruments at base of machine and then comparing results with vibration in the floor. While this is the only true check, it is most helpful to be able to predict the efficiency on a theoretical basis as a function of the frequency ratio F_d/F_n, as used in the following formula:

$$E = 100\left[1 - \frac{1}{\left(\frac{F_d}{F_n}\right)^2 - 1}\right]$$

where E = vibration isolated, %
F_d = disturbing frequency
and F_n = natural frequency

Tracing the disturbing frequency in an existing installation may be a toughie if vibration is sneaking out of an apparently isolated unit. Here's where it's wise to check suction or discharge piping, electrical conduits, braces, pipe hangers—everything vibrating in the area and every connection that might prevent the machine from moving freely on its mountings.

Efficiency chart shown on preceding page is a graphical presentation of the efficiency formula. It may be used to select required static deflection for a particular theoretical efficiency or to determine the theoretical efficiency of a particular mounting under consideration. *This chart should be used with caution—the results are only theoretical.* Keep in mind that the formula is based on massive floors of great rigidity as compared to stiffness of the isolating materials. It is also important to realize that a 90% value might be quite satisfactory for small equipment but the resulting 10% vibratory transmission could mean a large force as the equipment grows in size, speed and horsepower. As pointed out in *Balancing Rotating Machinery*, p 236, there is a pressing need for vibration standards to determine allowable efficiencies for a particular unit. To illustrate limitations of theoretical efficiencies, let us consider this . . .

Case-in-point. Say we are trying to provide 90%-effective isolation for a machine operating at 1000 rpm. In checking the efficiency chart we find the theoretical static deflection should be about 0.4 in. If the installation is to be made in a basement poured on grade, the theoretical figure would be correct and a double-deflection rubber mounting would be the economical choice. But since allowable floor deflections are 1/360th of the span, a 4-in. reinforced-concrete floor higher in the structure might easily have its own 0.4-in. deflection. If the very same machine were to be placed in this area, rubber mountings would probably be unsatisfactory and a standard 1-in.-deflection spring mount would be the proper choice.

Proceeding one step further, let us locate the machine on a wooden floor

Suggested isolation efficiencies

Equipment		Installed efficiency, %
Absorption units		95
Steam generators		95
Centrifugal compressors		98
Reciprocating compressors		
Up to 15 hp		85
20 to 60 hp		90
75 to 150 hp		95
Packaged air conditioners		90
Centrifugal fans		
Speed, rpm	Dia, in.	
800 and above	all	90 to 95
350 to 800	all	70 to 90
200 to 350	48 or smaller	*
200 to 350	54 or larger	70 to 80
Centrifugal pumps		95
Cooling towers		85
Condensers		80
Fan coil units		80
Piping		95

* Installed for noise isolation only

Minimum mounting deflections

Operating speed, rpm	Basement—negligible floor deflection	Rigid concrete floor	Upper story—light concrete floor	Wood floor
300	1.50 in.	3.00 in.	3.50 in.	4.00 in.
500	0.63	1.25	1.65	1.95
800	0.25	0.60	1.00	1.25
1200	0.20	0.45	0.80	1.00
1800	0.10	0.35	0.80	1.00
3600	0.03	0.20	0.80	1.00
7200	0.03	0.20	0.80	1.00

COMPENSATION FOR LOCATION is a factor to consider when isolating machinery. Here's where data on minimum mounting deflections are put to good use. Mountings can be built with safety factors to compensate for light modern office-building floors or easily excited resonances

←

CRITICAL AREAS demand these minimum efficiencies for air-conditioning equipment. In noncritical areas such as basements or warehouses a minimum figure of 70% will often suffice. While there are many types of equipment not listed here, table will help you set up efficiencies for others. Manufacturers can furnish data for their equipment

and factors in selection of a practical vibration mount

in an older structure. Floor deflection has been measured at 0.6 in. and the floor has little mass. For this extreme condition you might be wise to consider 3 in. of static deflection to maintain isolation at the original 90% figure. The lesson to be learned is simple: before selecting a material from the theoretical-isolation-efficiency comparison table atop the facing page, it is most important to correct static-deflection requirements in keeping with actual location of the machine. Except in those rare instances where the floor is extremely massive, mounting deflection must exceed floor deflection or the isolator will not be fully effective.

Selecting the isolator, be it a spring, rubber, felt or other, is the next step. Although it's agreed all mechanical equipment in motion vibrates, a properly isolated machine transmits so little vibratory energy to the structure that it need no longer be considered a vibration source: this is your goal in isolator selection. And isolating these push-pull forces means mounting the offender so that the structure is not called upon for anything beyond static support. If a series of more and more flexible mountings were interposed between the machine and floor, less and less of the vibratory force would reach the floor. As mounts were added, machine would gradually approach the condition of a free body unrelated to the structure. You must solve the problem of approaching this condition without interfering with operation of the machine and within practical economic limits.

Consider for the moment helical steel springs, rubber mountings and rubber pads as described on the following pages. They may be used singly or in series to isolate vibrating equipment. Each of these materials has its own natural limitations. It's because of these limitations that the isolation safety factor may be increased by using a material of greater static deflection. Remember, a minimum-deflection material will never solve a problem that demands better treatment. All isolation materials tend to fall into average-static-deflection categories. Since static deflection is the most important single factor in selecting a material, the table above will serve well as a theoretical guide to isolation.

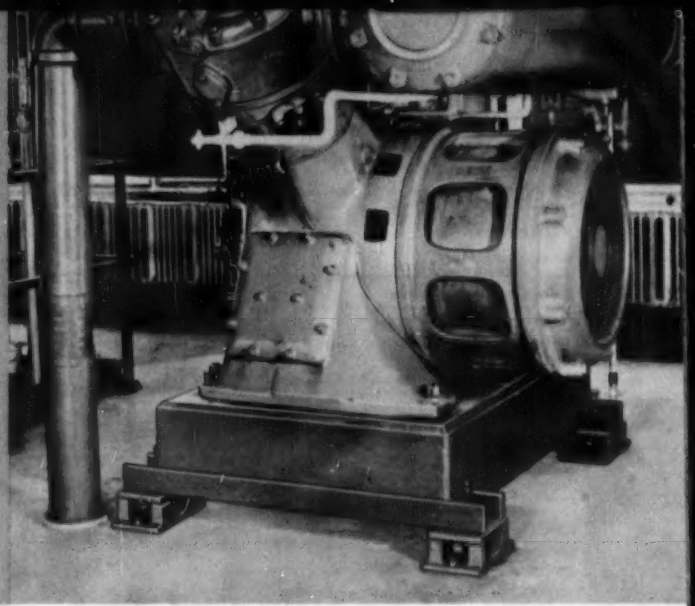
Damping characteristic of the particular isolation material is another factor to be evaluated. Since damping is a viscous resistance to motion its value for a specific isolator may further reduce the theoretical efficiency. Damping tends to prevent the natural free movement of machinery. It is typified by the dashpot and encountered in such everyday devices as hydraulic door checks. This damping force transmits vibratory pressures to the building.

Steel springs have so little inherent damping that it's not even a consideration. On the other hand, damping is so high for cork materials that natural frequencies are about three times higher than mathematical figures based on deflection would indicate. So experimental values must be used. Rubber materials lie somewhere between these two extremes. Now let's look at specific types of isolators.

Springs take high static deflection

Long service life teams with high isolation efficiencies to boost industrial use of steel-spring mountings. Where rubber-mount deflection, for example, is usually limited to ¼ in., a tough spring on low-speed equipment endures static deflections up to 14 in. This means the same equipment can be installed on a lighter substructure, with attendant savings.

Helical-coil springs are in common use. This type, when properly designed, cannot be overstressed. Coil pitch is limited so that even when spring is compressed solid and coils touch each other, spring material can take the strain. Springs may be made of hard-drawn wire, oil-tempered wire or a high-tensile material such as chrome vanadium.



NO MORE VIBRATION, shock or noise reach sensitive lab instruments; steel-spring mounts isolate this big air compressor

SPRING MOUNTS often include leveling

A properly designed set of bare steel springs is often an isolation package, complete in itself. But engineering here can be tricky: springs have to be proportioned for adequate columnar stability, and designed so they're deflected evenly if weight distribution is unequal at the four corners of the supported equipment.

This type of isolation is usually limited to equipment produced in volume. It's an excellent solution for identical repetitive use, where cost of the original design engineering can be spread out over a large number of units. Typical example is a small welding generator for maintenance work, which often uses four springs on the bottom to isolate it from the floor, or a commercial 1-gal paint mixer in common use.

A leveling bolt must be added to the simple steel-spring mount where loads vary considerably or supporting surfaces aren't level. This basic combination finds wide use on centrifugal blowers, compressors, chillers. Over a wide range of capacities, application method remains about the same. Machine rests on a fixed stop welded to the leveling bolt. After the machine deflects the springs, bolts are turned to make everything level. Mountings often have a neoprene pad on the bottom for noise isolation and antiskid protection.

Spring fatigue is a minor problem in isolation work; amplitude of vibration (spring movement) is very small. An isolated diesel engine may vibrate 0.04 in. If the support mounting has eight active coils, each coil would move just 0.005 in. Stress cycle is limited so that the loading is static. Springs for this mount are probably designed to operate at about 60% of solid stress, so with limited movement they'll last indefinitely. Corrosion is overcome by cadmium-plating and neoprene-dipping standard metals or by using corrosion-resistant stainless steel, spring brass or phosphor bronze.

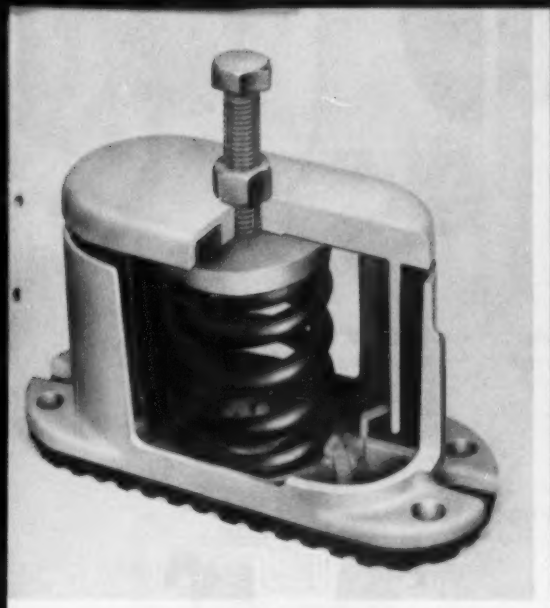
Bare springs provide the best vibration isolation because there is virtually no viscous damping in the spring itself. But sometimes damping may be desirable to limit movement.

Damping here is a viscous resistance to motion provided by friction within the mounting. A classic example is the dashpot: movement of a piston in a cylinder is resisted by oil under it. Piston can lower only slowly as oil escapes around its rim. Theoretically, excessive start and stop motion of an engine mounted on steel springs could be limited by a series of dashpots placed between engine and structure. In practice, dampers are usually built into the housings of standard steel springs.

Damped-spring setup is shown in first photo, right-hand page. Spring is contained within two telescoping steel housings separated by a layer of firm sponge rubber. Rubber doesn't slide between the two housings but adheres to each surface by friction. Vertical shearing action on the rubber has damping effect to control start and stop movement. Horizontal pressure on the material limits translation as damping increases.

Leveling bolt passes through a tapped hole in upper casting and rests on a plate which compresses the spring. Weight of equipment first closes the horizontal gap between the two castings. Turns on adjustment bolt compress the spring, which was selected to handle load at that point. As spring develops an upward force to balance the weight, equipment remains at a constant elevation. Adjustment bolt raises the upper steel housing, restoring clearance between the two housings; more turns level the equipment at desired height.

When simple damping isn't enough, adjustable dampers provide more resistance, above center. A semicircular plate is placed behind the damping material, which is solid neoprene rubber rather than sponge. A horizontal screw controls pressure against the damping material. This type of mounting is needed under rough-service impact conditions—punch presses, drop hammers, etc—for positive control of spring oscillations.



DAMPED-SPRING MOUNTING, left, has semicircular sponge-neoprene inserts to damp motion during starting and stopping. Adjustable dampers, right, provide more resistance

RESILIENT SNUBBERS in this new design are partially shielded from oil and dirt

and damping action

Many types of machines—grinders, boring mills, lathes, small compressors and most punch presses—don't need holding-down bolts. Isolators are set right on the floor, and no holes need be drilled or anchor bolts used. The machines' weight on the floor is practically static, so isolators can absorb most dynamic forces generated. In this case, machinery can be moved easily from one floor area to another as production flow changes.

Foundation bolts are needed for machines exerting large unbalanced forces (crushers), with large overhanging weights (some inclinable punch presses) or machines subject to belt pull from separately mounted motors. Large variations in bearing load can cause "walking" of nonisolated machines.

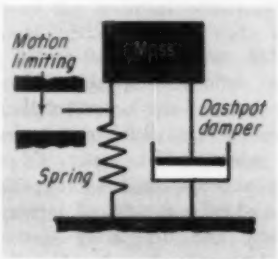
Intermediate fastening is needed for some surface grinders and similar machines. Isolators are either held to floor by ribbed rubber or cemented on ⅛-in.-thick felt pads. Bond strength runs to 65 psi, so when the machine has to be moved, cement must be dissolved with a special solvent. For critical applications where noise and high-frequency disturbances accompany the lower-frequency vibrations, synthetic-rubber sound pads can be placed under the isolators for best results.

A mount subject to heavy impact and shock can use simple damping adjustments to prevent sudden spring recoil, checking excessive machine motion or bounce. When a punch press strikes its blow, the springs are displaced by the impact, absorbing the shock. Machine descends slightly after the blow, then the springs come into action, restoring the press to its original position. Dampers keep motion from continuing, and the punch press tends to come to rest after each sudden impact.

Enclosed-spring mount, photo, far right, keeps out dirt with a telescoping housing. Resilient guides hold the upper and lower housings in their relative positions and provide horizontal vibration control. Pressure on guides is preset but their damping action may be changed.

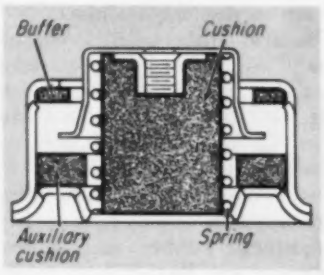
Spring-mesh dashpot all-metal system, right, uses a stainless-steel knitted-wire-mesh cushion and helical spring. System is wed into one resilient element: buffer allows gradual engagement for radial or negative motion limitation and shock absorption, cushion provides load tolerance and damping, spring insures low natural frequencies and isolation. The auxiliary cushion works during temporary overloads, also provides extra shock protection. This mount handles the lighter loads—instruments, aircraft equipment and shipping cases for delicate instruments.

Dashpot is heart of resilient mounting



Spring-mass-dashpot

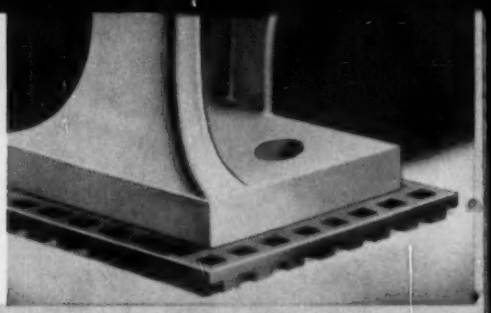
Spring isolates vibration, dashpot damper limits motion of the mass. Classic spring-mass-dashpot system is also basis for the all-metal mounting shown below



Unit vibration mount

Knitted stainless-steel wire-mesh cushion, helical spring and dashpot are wed into a resilient mounting element for light loads

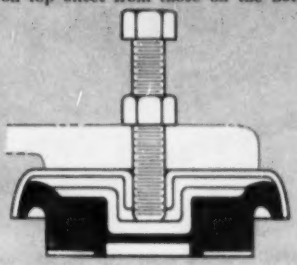
1 CROSSRIBBED pattern is molded into top and bottom of a neoprene sheet to absorb vibration. Machine to be isolated statically deflects the rubber pad by its gross weight



2 CELLULAR design has square pockets on top offset from those on the bottom

Mounts that save space, weight, cost

Rubber is a widely used isolator, cutting vibration, shock and noise. It comes in many forms, can be molded to many desired shapes and stiffnesses. Molded-rubber parts have better hysteresis (internal friction) than metal springs. Weighing in at a minimum, they also save premium space and can be bonded to metallic inserts. While natural rubber is still in vogue, synthetics including neoprene, Buna-S and Buna-N are popular. Buna-N comes under trade names of Hycar, Perbunan and Chemigum. Butyl and Thiokol see some service duty, but only in special cases to handle unusual requirements.



6 LEVELING design allows large deflection while under shear and compression

RUBBER in action rolls with the punch

Rubber mountings see widest use where deflection requirements are fairly low and don't warrant the use of steel springs. Rubber is a viscoelastic substance; like water, it's practically noncompressible. Ingredients can be added to compound, increasing viscosity and decreasing elasticity. That improves damping but limits load that the rubber can carry without excessive drift in the material.

Hardness of rubber is scaled on the durometer from zero to 100. The softest rubber common for isolators rates about 30 durometer, hardest about 70—the harder the rubber, the greater its damping qualities.

Natural rubber offers a combination of mechanical properties: minimum drift, maximum tensile strength and elongation before failure. Another important point: it's least expensive. But uses are limited by deterioration when exposed to hydrocarbons, ozone or high temperatures.

Synthetic rubbers step in here. Neoprene and Buna-N both exhibit excellent resistance to hydrocarbons and ozone. Buna-N stands up well to relatively high ambient temperatures. Another synthetic, Buna-S, is widely available and therefore sees much use. Some silicone-rubber compounds stand up to temperatures ranging from —100 to +400 F. Compression set tends to increase greatly at high temperatures, but stiffness stays about the same after long exposure.

Vibration isolators made of rubber or rubber-and-metal are available in compression and shear types for heavy and light loadings, see box at right. Compressive units generally find their place in high-load or high-shock applications; shear types handle light loadings. Rubber comes in sheets to be cut to size and installed under machinery, and it's made into numerous designs as individual compression mounts. For use in shear, rubber is usually bonded between metal faces and load is applied parallel to the faces.

Let's look at some typical designs—some of the many hats this versatile material puts on to fight vibration daily on all possible fronts.

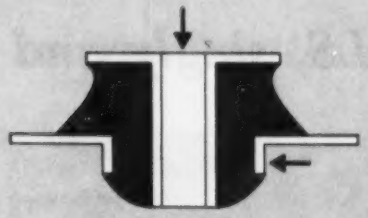
Molded neoprene sheet, Fig. 1, is made with crossribs running at 90-deg angles. Crossribbed design helps absorb vibration energy. Machine to be isolated must be set on pad so as to deflect it by its own gross weight (static deflection). This design tackles loads up to 50 psi.

Cellular design, Fig. 2, is another pattern for neoprene good to 50 psi. Square pockets or suction cells are molded into both surfaces, with cells on bottom offset from those on top. Cell design improves flow of resilient material as well as deflection of pad under load.

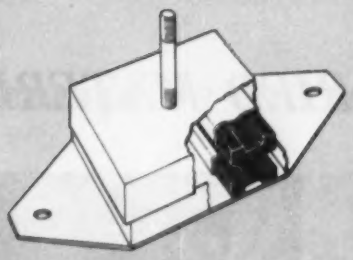
Balanced compression-and-shear, Fig. 3, combines benefits of large deflection ratings and high load-carrying capacity. This combination is one of the most effective for all-'round vibration isolation. Rubber in compression carries higher stresses than equal in all directions, resilience is the same in all planes. Then vibration is successfully isolated whatever side exciting force attacks from.

X design, Fig. 4, keeps high damp- in shear. When deflection rates are ing properties of neoprene loaded in shear, but this mounting is engineered so it can't be overloaded. An X-shaped rubber insert fits into a metal mount, but with no rubber-to-metal bonding. Under normal loading, rubber element acts in shear at points of the X. When load exceeds the rated capacity, rubber goes into compression. A metal unit mounting may incorporate one or several of these X-shaped inserts.

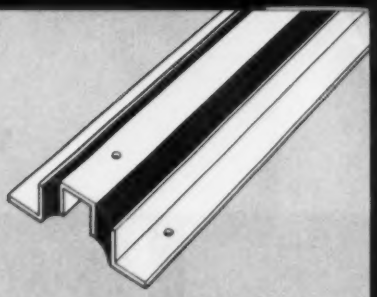
Channel design, Fig. 5, has a double function: it's used for mounting machinery on floor or suspending it. Either way it takes care of fre-



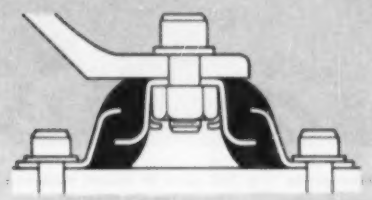
3 COMPRESSION AND SHEAR balance, produce high deflection ratings



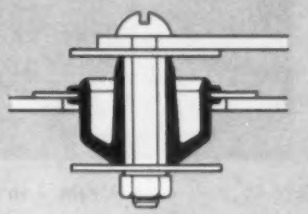
4 X-SHAPED INSERT has damping of rubber in shear, can't be overloaded



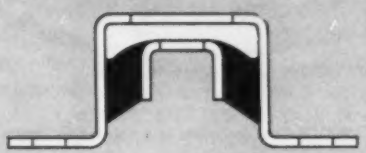
5 CHANNEL DESIGN is equally good to mount machine on floor or hang it



7 TELESCOPIC metal insert keeps machine from toppling if rubber should fail



8 SLEEVE type for light loads has almost uniform flexibility in all directions



9 SAFETY CHANNEL for overhead mounting hangs on even if rubber fails

quencies in region of 1000 cpm and above. Channel comes in various lengths, usually handling a load of 50 lb for each inch of its length.

Leveling design, Fig. 6, incorporates a large amount of neoprene to permit big deflections under both shear and compression loading. Neoprene is used for its high resistance to oil, grease and caustic solutions.

Telescopic insert, Fig 7, is stable in all directions in a horizontal plane. Vertically interlocking metal flanges up its factor of safety from unforeseen dynamic forces. Even if rubber fails completely—in a plant fire, let's say—machine is held safely, can't topple from its foundation.

Sleeve type mounting, Fig. 8, must be placed in same plane as center of gravity of the machine it supports. Then it has almost uniform flexibility in all directions, and so it's correspondingly effective against disturbing forces from any direction. Lightweight and soft, sleeve mounting handles load ratings from ½ to 45 lb per unit, isolates a wide range of frequencies. Its specialty is isolating electronic equipment and smaller precision machinery.

Safety-channel mount, Fig. 9, sets rubber in metal channels for strength. Safety is always a major consideration where machinery is hung from above. In this design, an outer wing channel surrounds the smaller inside channel where mounting is bolted to a common base. Inside channel carries the load. So mounted, machine cannot be released if rubber fails or is destroyed—it's safe up to breaking point of the metal channel. Channel mount isolates vibration in any direction, stressing the rubber in shear. Mountings are designed for loads from 24 to 700 lb, temperatures up to 150 F.

Sponge rubber is also used to isolate vibration. Sponge contains numerous minute air or gas pockets. As load is applied, the air or gas compresses, making overall stiffness of the material relatively low. Sponge rubber comes in slabs which can be cut into pads of needed size, or it's molded into intricate shapes.

A new fluorosilicone sponge compound features dense, uniform, nonabsorbing closed cell structure. Like other silicone rubbers, its physical properties remain good over a wide temperature range. It is highly resistant to fuels and oils and can be compounded with other ingredients to improve vibration-damping qualities, adding to its versatility.

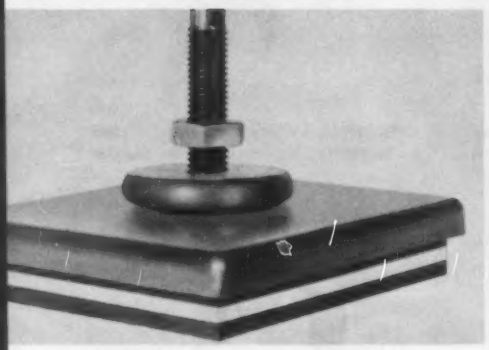
Rubber isolators take four forms

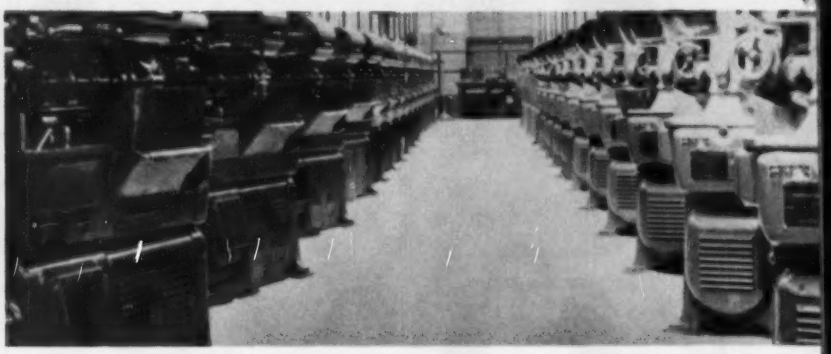
Compression ***Tension*** ***Shear*** ***Balanced compression***

Effective vibration control calls for absorption of all possible modes of motion. A flexible mounting that's soft in only one direction fails to isolate all the modes, may not do the job you want.

Rubber isolators take four forms: *Compression* mount alone may be unstable because of excessive softness in lateral direction. *Tension* alone can be oversensitive to injury, or bond between metal and rubber may be weak. *Shear* is acceptable, but has drawback of excessive lateral stiffness. *Balanced compression and shear* depends on proportioning compression and shear strength to achieve uniform softness in all directions.

VARIED MATERIALS, singly and





WOOL-FELT isolation is a natural for many applications. These grinders, right, work in relative peace with felt mats to isolate each one

FELT comes in many densities, supplies its own lube

Felt is a fabric built up by the interlocking of fibers through mechanical work, chemical action, moisture and heat; without spinning, weaving or knitting. Felt is made up of one or more classes of fibers. Wool felt consists of new, reprocessed and reused wool, with or without a mixing of animal, vegetable and synthetic fibers. Felting process utilizes natural crimp and interlocking characteristics of the fiber. Result is a well-compacted fibrous material up to 3-in. thick.

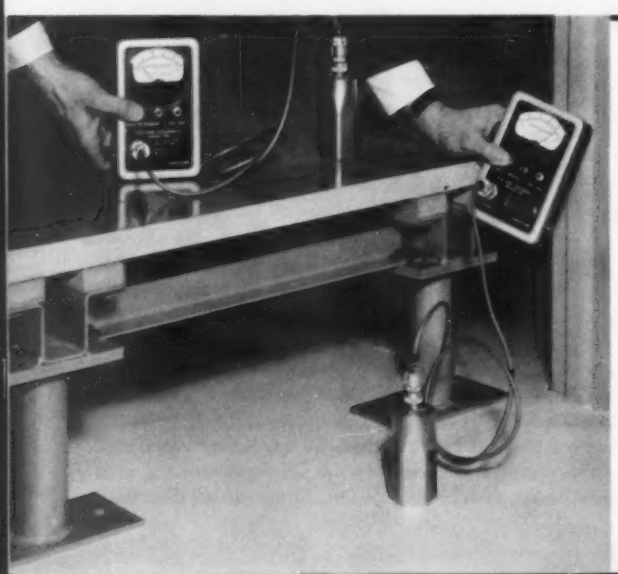
In virgin wool, fiber's inner core is stretched, supported by the outer cortex. Compare it to a stretched rubber band coated with enough cellulose acetate to support it while stretched. When treated with heat, moisture and lubricating and swelling agents such as soaps and alkalies, the supporting layer becomes plastic and releases the elastic core. Result is immediate lengthwise contraction. Because of uneven forces involved, the fiber contracts like a bimetallic strip, tending to curl into a tangled mass. Entanglement of many such fibers results in shrinkage which we call the "felting" process.

Wool felt comes in densities ranging from extremely soft to hardness of wood. It's resilient, will not ravel, shred or fray when cut. It resists oils, greases, organic solvents, cold, dryness, sunlight, ultraviolet radiation and ozone. And wool is a naturally oily fiber (from which lanolin is extracted), so oil lubricates the wool fibers as they pulsate while damping vibration.

Felt can be cut into small pads of desired area and placed under equipment to be isolated. Special cement is often used to hold the pads in position. A solvent releases the felt when the machine has to be moved.

Force-deflection curve for a felt pad in compression is fairly linear for deflections great as 25% of thickness. But after that stiffness increases rapidly. At 50% deflection it's about ten times as great as at the 25%-deflection point.

Besides the simple pads, felt comes in various designs of self-contained leveling mounts, photo, above left. While usual loading runs about 50 psi, loadings as high as 125 psi have been carried on ⅜-in.-thick felt mounts. But the felt must be engineered for greater density and firmness to stand up under the high loading.



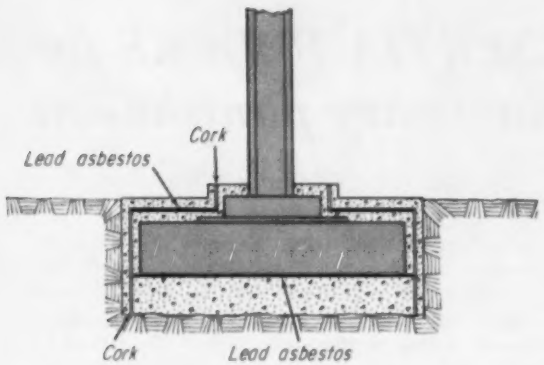
GLASS-FIBER blankets have

Blankets of glass fiber are used as the resilient element in "floating-floor" construction, left, because of their vibration-damping properties, chemical inertness and resistance to moisture. Of course, glass fiber is also incorporated in machine mounts of varying designs, with and without built-in level control, just as are natural wool and many other materials.

Deflection of a resin-bonded glass-fiber blanket depends on density of the blanket. In floating-floor constructions, for example, velocity-amplitude of the structural element is about constant at low frequencies. The lower the rigidity of the elastic layer, the lower will be

◀ **GLASS FIBER** stops 80 micro-in. of vibration

in combination, complete the team



HEAVY-DUTY MATS of lead-asbestos set under building columns dampen shock and noise

LEAD-ASBESTOS pads

find their use in building construction and under heavy machinery to dampen vibration. The pads usually consist of two ⅜-in. layers of felted asbestos material. separated by a No.-20-gage steel sheet which provides support for handling. Entire mass is then encapsulated in a ⅛-in.-thick lead shroud, used as shown above.

Lead-asbestos pads are effective because dissimilar materials in contact tend to resist vibration transmission. Lead, noted for its good vibration-damping properties and resistance to corrosion, is ideally suited for the shell.

Lead also withstands the tremendous vertical loads of skyscrapers. Mats placed under the columns of a building keep vibration from nearby railroad tracks from traveling back into the structure.

valuable dampening properties

vibration amplitude at high frequencies. But the benefit of reduced vibrational energy at high frequencies is offset by the risk of increased noise transmission at the low frequencies.

Floating floor shown is isolated from the concrete subfloor with glass-fiber strips, to protect delicate electronic equipment installed on the floating floor from vibration produced in the rest of the plant. Vibration reading on concrete subfloor is 90 micro-in. while reading on the floating floor is only 10 micro-in. The two meter readings are proof positive of what can be accomplished by well-engineered vibration isolation.

CORK is an old-timer

An old standby, cork still turns in a good day's work isolating vibration, shock and sound. Slabs are made by compressing ground cork particles under high pressure, then baking with superheated steam. Natural cork, the tissue of the cork-oak tree, has numerous minute air cells that become compressed along with the cork particles.

Cork mountings have been deflected up to 24% without showing noticeable lateral expansion. One big difference between cork and rubber: cork is compressible, while rubber is not and must be allowed a "bulge space" where it can deflect.

When cork is loaded in compression, its stiffness continues to increase with deflection. Loads up to 60 psi have been handled. Mats are moisture-proof, easily cut with a saw.

Cork can be used under an entire foundation, helping speed up the concrete pouring. It's installed on sides of foundations, too, and lends itself especially well to use as a slab loaded in compression, set directly under the base of a machine or under an inertia block.

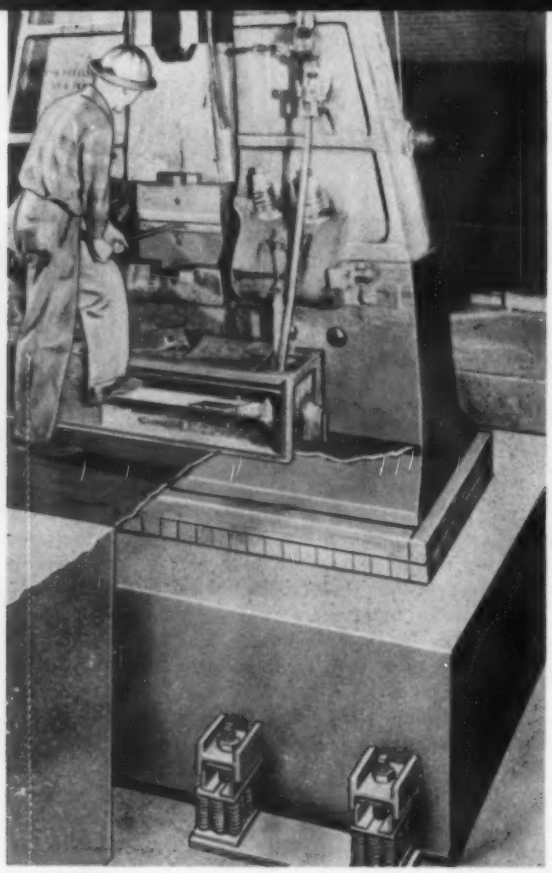
FABRIC takes big loads

Neoprene-impregnated fabric reduces heavy impact shock and high-frequency vibration and noise. It's made of layers of tightly twisted, closely woven lightweight cotton duck. Each layer is impregnated with rubber compound. Layers are built up to the needed thickness and vulcanized together. Neoprene used is a grade for special applications, so the finished product resists hydrocarbons, withstands temperatures from —50 to +220 F.

Static loadings up to 1500 psi are handled—fabric sees major use under heavy bridges, forging hammers, etc. Damping value is about four times that of natural rubber, 100 times better than steel. Shore durometer hardness is 90. Big advantage: even over long periods, creep deflection is almost nil.

PLASTIC stays resilient

Synthetic-rubber-like plastic, bonded onto burlap, has qualities of rubber but retains resiliency over long periods and does not oxidize or harden. Oil won't affect it. It's used in single ⅜-in. thickness for loadings up to 30 psi, double thickness to 50 psi. When plastic is placed under large areas, an edge surface is needed for expansion.



FORGING HAMMER "floats" on a spring-mounted concrete-inertia-block foundation. A coin will stand on edge near the hammer

INERTIA BLOCKS for the heavy punishment

Forging hammers, pulverizers, presses, generators and compressors are often installed on a large concrete foundation which acts as a floating inertia mass to reduce movement and as a rigid continuous machine base. Large low-speed engines usually need concrete foundations for two reasons: (1) Added mass reduces amplitude of movement caused by forces and couples generated in the large machines. Mass of the foundation is based on unbalance data, varies from a weight equal to engine's weight up to six times engine's weight, depending on balance of the particular machine. (2) Low-speed engines are seldom close-coupled to equipment or factory-mounted on a structural-steel base as are high-speed units, so concrete foundation assures rigid connection between engine and driven equipment.

Transmitted vibration may be a problem, as well as actual movement of machines. Then massive concrete foundations won't supply the complete answer. No matter what its mass, foundation will still move slightly, sending out pulse waves through soil that touches it. It's important to know type of soil under the plant, especially when engine is on ground level or in the basement. If engine generates disturbances at frequencies close to frequencies of the soil, isolation becomes a must so unbalance won't excite the soil—otherwise there may be objectionable transmission as far as a mile away. This is especially true where soil is clay, rocky or spongy and wet—water is an excellent vibration conductor.

Cutting the floor out for about two in. around perimeter of engine's foundation has been tried, but is no sure solution. Vibration can travel through the soil to building columns, then spread up into the building. Usually foundation itself must be isolated from soil and building structure to limit vibration transmission.

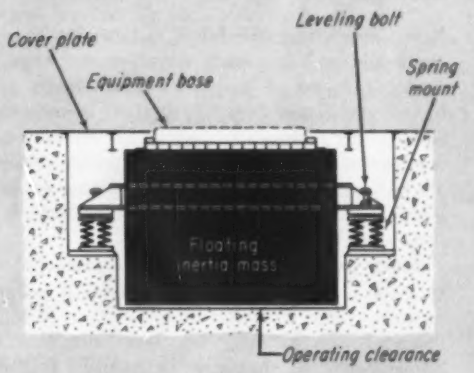
A well-defined analytical theory covers selection of isolation material for use under the concrete. In general, proper choice depends on disturbing frequency generated by engine. A vibration consultant is needed here.

Sand has been tried as a vibration isolator under concrete. But theory and practice both indicate that an efficient isolator must be resilient. There's no resiliency in sand—it packs into a mass under the foundation.

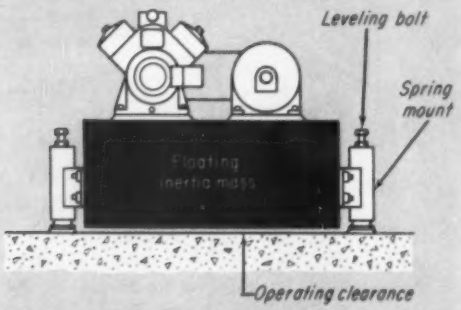
Cork is commonly used under concrete foundations. It's an excellent noise isolator, but only good for high-frequency vibration. Use it with great caution to avoid resonance with high-order harmonics of engine vibration.

Steel-spring isolators are most efficient, have been used successfully to "float" all types of foundations. Photo, left, shows a large hammer foundation supported on steel springs with mechanical snubbers to control movement. Lower sketch shows typical construction of inertia mass combined with long deflection springs.

Inertia blocks may be placed in recess or on the surface

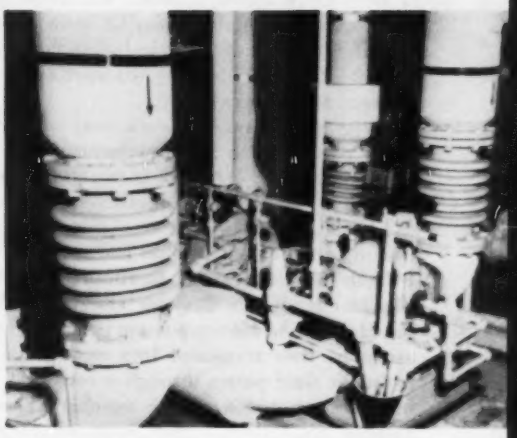


BELOW-FLOOR-LEVEL arrangement for floating inertia mass keeps bulky foundation out of sight



ABOVE-FLOOR-LEVEL arrangement uses long deflection springs to float this small air compressor

JITTERING FLEXIBLE HOSE barricades vibration trying to travel to other plant equipment. Hose gives refrigeration compressor freedom to float on springs



EXPANSION JOINTS sop up most vibration and also lateral deflection of these small turbines

Don't forget FLEXIBLE CONNECTORS

A machine may be dynamically balanced and carefully isolated, but unless its piping, conduits and shafting are correspondingly isolated, they can form a broad highway letting vibration pass freely in and out. Piping systems, under improper conditions, are near-perfect conductors of vibration and noise. Equipment is available to throw up a highly efficient roadblock, however. Flexible piping, pipe hangers, pipe snubbers, expansion joints, ball joints, flexible drive-shaft couplings, flexible bushings—all fit in here. Any kind of flexible connection that breaks the rigidity of the piping will greatly reduce vibration transmission from its network of equipment.

Flexible piping, set into the line in short lengths on suction and discharge sides of pumps, compressors, etc, will isolate a piping system from source of vibration. This piping bars noise and vibration while allowing free passage of fluid being pumped—install it close to source of vibration for best possible results.

Flexible pipe hits the battle line in variety. Wire-reinforced wrapped-fabric section of rubber pipe is usual for water lines. Its low acoustical impedance reduces noise transmission and diaphragm-like breathing action prevents water hammer. Use it for pressures up to 250 psi.

Liquid and gaseous refrigerant lines are common in air-conditioning units in general industry. These fluids embrittle rubber, so rubber pipe is out of the picture. Best all-'round pipe for this application is seamless, flexible bronze tubing, encased in a protective cover of braided bronze, left, above. For heaviest duty and corrosive service, stainless steel and other alloys are advisable.

Besides carrying system vibration, piping will expand or contract in varying amounts with any temperature change, depending on composition and dimensions. Repeated flexing may strain pipe, fittings or connected equipment, often with disastrous results.

Expansion joints installed axially to vibration absorb this movement, isolate noise and vibration, compensate for misalignment. Duck-reinforced rubber joints are shaped into one or more arches. A wide range of natural and synthetic rubber handles temperatures as high as 250 F. There are many designs on market.

For tough fluids like steam, corrosive chemicals, oil and gas, or for high-pressure systems, joints in welded-diaphragm packless construction are made of stainless steel or other alloys. These withstand temperatures from —300 to +1800 F, and up to 1000 psi. Corrugated-metal joints are also available; they take up axial, lateral, transverse and vibratory movements and very high pressures. Some corrugated-stainless-steel designs have tested at pressures from vacuum to over 3000 psi, temperatures from subzero to above 1000 F.

Bellows molded of Teflon compound are used for expansion, flexible and vibration joints. Bellows are designed for —100 to +450 F, operate over a wide pressure range including full vacuum.

Swivel joints allow rotation or other relative movement, yet contain and seal the fluid. Made of steel, cast iron, bronze, aluminum or other rigid materials, these joints usually withstand same environment, pressures and types of service as the rest of the piping system they isolate. Low-pressure joints operate from 28-in. vacuum to 1000 psi; high-pressure joints run up to 15,000 psi. Most joints will work at 250 F; special designs permit lows of —300, highs of +700 F.

continued

Hydraulic rotary shock absorber, top right, is used to keep down water hammer, steam-induced vibration, vapor lock, duct rumble or cavitation-induced shock. This unit allows free movement including contraction and expansion of the line, but absorbs inertia or pulsation both longitudinally and laterally.

An outer reservoir houses four working chambers and a reserve chamber. Movement of the wing shaft in either direction causes fluid in two chambers to be forced through a valve into two other chambers, dissipating shock energy. Resistance is governed by size of valve opening and amount of fluid allowed to pass through it.

Hydraulic vibration snubber, center, works as a stop or restraint for dynamic vibration and shock loads. Rapid vibration movements are restricted by the snubber assembly, then translated into more-gradual motion as hydraulic fluid passes through a restricted orifice in the reciprocating piston of the snubber cylinder (another dashpot application). Ball joint on each end of the snubber permits alignment to prevent binding.

Ball type flexible struts function as positive restraints in process systems where a stop is needed in one direction, yet some movement must be allowed in other directions. A flexible ball type joint is located at each end of a solid strut in this design.

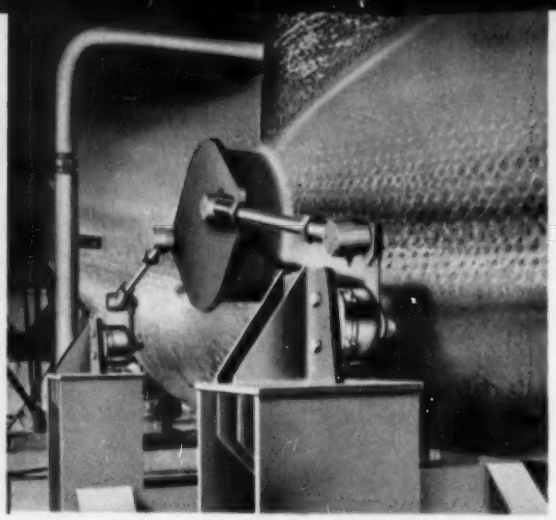
Rigid suspension hangers by nature can't isolate vibration. They'll transmit it freely from ceiling to pipe or suspended equipment and vice versa. Shock and vibration are often transmitted over entire length of piping, and may cause excessive vibration in portions with a frequency close to that of the transmitted vibration.

Vibration hangers or sway braces, top sketch, provide both suspension and isolation. These flexible hangers accommodate thermal changes—they don't interfere with the pipe or restrain its normal movement—but they're not used to cushion or absorb undesirable piping movement caused by shock and resonance. A variable-load spring fixture is adjusted by turning the turnbuckle until indicator shows correct cold load on the spring scale. When pipe reaches its hot operating position, hanger should be checked to see that the correct operating load is carried—that assures top efficiency.

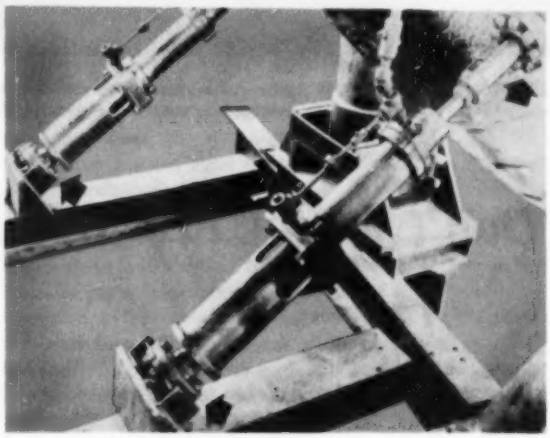
Spring-loaded constant-support fixture, second sketch, consists of a spring actuated through a lever such as a bell crank. As load rises against spring displacement, bell crank's position changes and a reduced lever arm compensates for rising characteristic.

Flexible couplings prevent vibration in direct-coupled machines, third sketch, by taking care of misalignment. Aligning machines properly should always be first step in installation, but even so, misalignment will occur for various reasons during a machine's life. There are two basic ways to produce a flexible coupling: a yielding element such as rubber is used, or mechanical design provides movement between rigid parts.

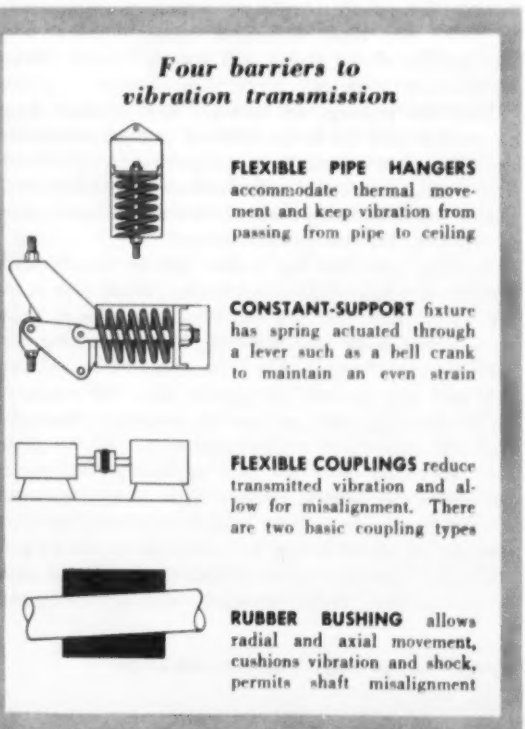
Rubber bushing cushions gears, sprockets and bearings to dampen vibration and alleviate misalignment problems. An inner and an outer metal sleeve are separated and held by a wall of rubber, bottom sketch. Rubber allows radial and axial motion of each metal part in relation to other, but no movement at bonding surfaces.



HYDRAULIC ROTARY SHOCK ABSORBERS dissipate energy here by metering fluid under pressure through a controlled orifice



HYDRAULIC VIBRATION SNUBBERS with ball joints at ends bypass fluid through restricted orifice in reciprocating piston


Four barriers to vibration transmission
FLEXIBLE PIPE HANGERS accommodate thermal movement and keep vibration from passing from pipe to ceiling
CONSTANT-SUPPORT fixture has spring actuated through a lever such as a bell crank to maintain an even strain
FLEXIBLE COUPLINGS reduce transmitted vibration and allow for misalignment. There are two basic coupling types
RUBBER BUSHING allows radial and axial movement, cushions vibration and shock, permits shaft misalignment

TAPE applied by hand damps out vibration

INSTALLING DAMPING TAPE on the shell of this jet plane takes no special skills. Decay rates run to 1000 db per sec

Damping, the removal of energy from an oscillating system, brings up one main practical problem: how to obtain enough damping without excess weight or undue mechanical complexity. When vibration affects metal panels, damping tapes are a good answer.

Tapes reduce metal vibration by converting mechanical into heat energy. The layer of tape clings, actually changing natural frequency of the panel. This provides damping efficiency beyond that possible if mass or stiffness alone are added to the metal sheet.

Viscoelastic adhesive holds tape's annealed aluminum-foil backing to skin panel of a jet plane, right. After tape is applied, it's sprayed with a zinc-chromate primer, then with a white acidproof enamel to seal the edge and keep out airborne moisture. Damping lining is covered with preformed spun glass fiber. This "high-tack" tape is also applied to air ducts, and wherever sheet metal presents a vibration problem.

Another tape design uses a lead-containing vinyl to coat woven-cotton or glass fabric. This base is covered with aluminum foil on one side and with pressure-sensitive adhesive on the other. Lead's wide-range high-decibel damping characteristics are combined with the strength and flexibility of vinyl and glass or cotton.

A special design isn't needed for each application, though. Not the least beauty of tapes is that you can superimpose one on another until you get the damping effect you want. High damping at low frequencies, usually the most troublesome, becomes possible. Good damping is obtained over a reasonably wide range of frequencies, from below 40 to over 6000 cps. Damping effect can be predicted reliably from theory, minimizing trial-and-error. Built-in thermal barriers handle those "special" cases that seem to come up so often.

COMPOUNDS are sprayed or brushed on

Compounds of viscoelastic material are sprayed or troweled onto metal plate to reduce structurally borne noise and vibration. These compounds often render metal acoustically equivalent to a sheet of cork.

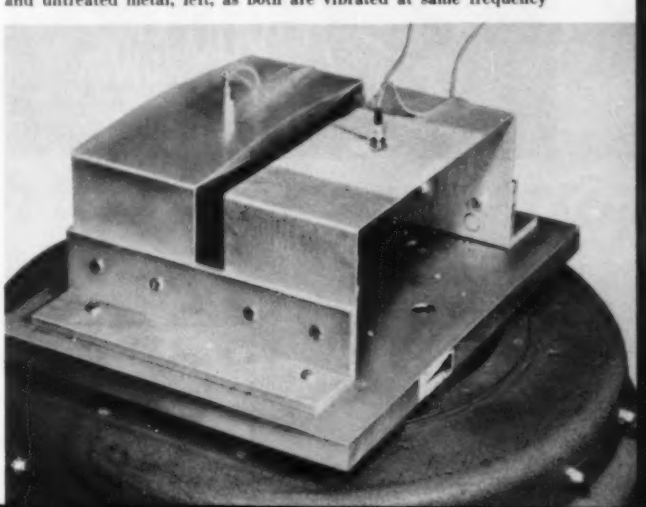
Compounds damp noise transmitted along structural paths through sheet metal, and also will deaden the drumming noise created by vibration or thermal movements of metal plates. They're applied to sheet metal used in air ducts, plenums, curtain walls, business machines, computers, transformers, metal doors, pumps, fan scrolls, vibratory feeders, wherever damping is needed.

High-damping viscoelastic material, photo at right, provides a decay rate of 35 to 55 decibels (db) per sec, compared to the 3 to 5 db-per-sec vibration-decay rate of some mastics. The viscoelastic material is handled like a coat of paint, dries to a smooth finish, is nontoxic and nonflammable. It resists alkalies, grease, gasoline and aliphatic oils.

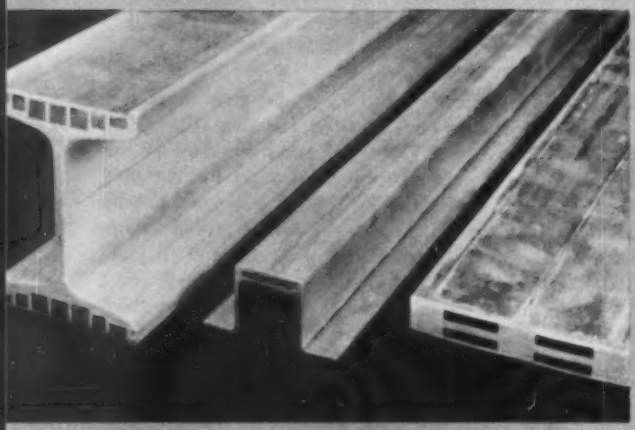
Mastic undercoating applied to your car reduces noise by viscoelastic damping. There's wide industrial use for these mastic deadeners, too. Some are soft enough after drying to indent with the thumbnail, but most are hard and seemingly brittle at room temperature.

Many of the mastic deadeners use asphalt base, either cut-back or emulsion type, with solid content varying from 65 to 85%. Other damping agents are bituminous mastics, glass-fiber blankets, asphalt felt and a number of similar materials. Different makers incorporate various fillers and fibers, depending on purpose and price.

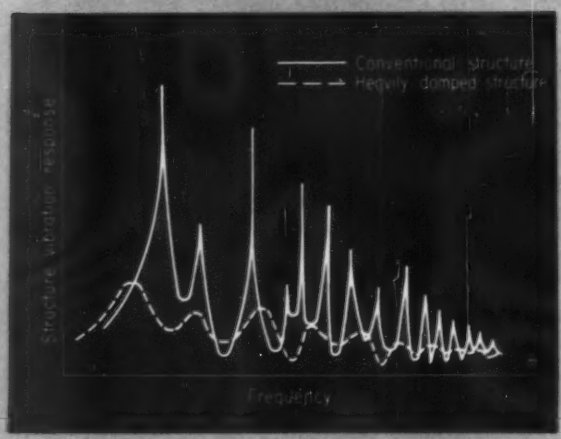
COMPARISON of viscoelastic-compound-treated sheet metal, right, and untreated metal, left, as both are vibrated at same frequency



COMPARING VIBRATION of the undamped beam, left, and the internally damped beam, right, at same resonant frequency



ALUMINUM I-BEAM has 14 steel inserts. Aluminum channel has one insert, rectangular section has four steel inserts



STEADY-STATE VIBRATION of undamped and damped beams points up difference. Both are functions of excitation frequency

STRUCTURAL DAMPING

Historically, accepted practice has worked toward developing better vibration isolators, applying them more effectively. And this is still the practical solution, especially where vibration is limited to fairly low frequencies. But higher operating speeds, much higher frequencies can place well-nigh intolerable strains on conventional isolators. For extreme cases, engineers are thinking of a new solution: why not let the machines vibrate, and build high-energy-dissipating mechanisms right into structural members of the plant itself? But this solution requires specially designed structural supports.

I-beams, channels and angles are available with longitudinal cells through entire length; an insert in each cell is separated from walls by viscoelastic damping medium. Sheets and thin-section beams are laminated with metal and plastic, separated by viscoelastic material. In flexing under impressed vibration, inserts slide against cell walls, laminations against each other. But viscoelastic property impedes sliding, and most resonance energy is absorbed in straining this layer in shear.

Low structure-vibration response of built-in damped members is compared with response of conventional members in graph, left. Top photo shows two simple cantilever beams mounted in a vibration exciter. Beam on left is solid aluminum, other has built-in damping. Both are tuned to same resonant frequency, but damped beam at right resonates far less than the other.

Fatigue life of a damped member should be longer because stress level is reduced. Damped pieces operate well across a wide range of frequencies, with extremely flat vibration response up to 2000 cps.

One disadvantage: damped members have less load-carrying capacity than same-size undamped members. For equal stiffness, structural damping imposes a slight weight increase. Same cross section cuts load capacity.

Damped members are also suited for use as "fixes" in existing systems. A cell-insert strip works much like the tapes in damping long structures. At present, big applications are in new plants in the electronics, missile and aircraft industries. But structural damping can be applied in large or small buildings, wherever vibration problem is severe enough to warrant their use.

Acknowledgments

POWER is deeply indebted to the many manufacturers of vibration isolators for literature, illustrations and technical help. We especially thank these individuals:

R E Batherman, E E Blaurock, V V Cerami, C E Crede, P Davey, L L Eberhart, J P Gnaedinger, H Harris, J Harris, H H Hile, W A Keetch, B Marcin, N Mason, A S Miceli, G W Painter, J E Ruzicka, D Sloan, W W Soroka, J Spachner, E W Stothart, J L Strong Jr, E E Ungar, D H Vance, P N Wheeler, J F Wiss, J A Zurbrigen

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NO. 50: CURRENT TRANSFORMERS

Plant Electrical Fact File

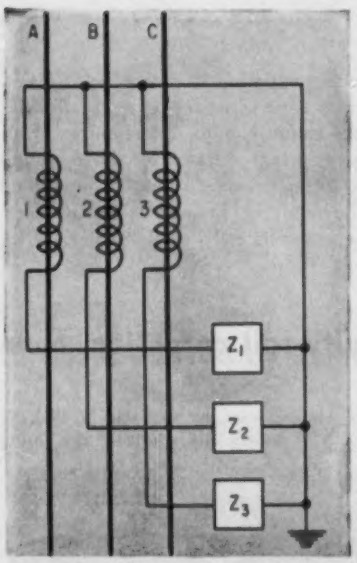
3 hookups for current transformers

By NORMAN PEACH, Associate Editor

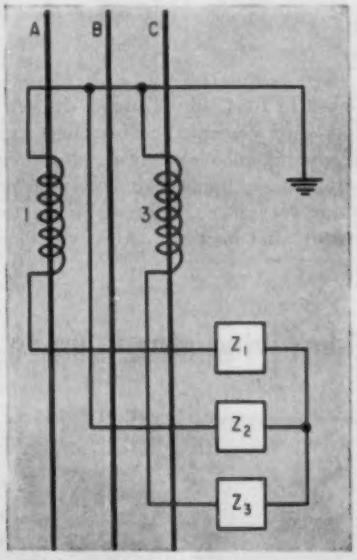
Current transformers see wide use with ac instruments and protective relays. We've already delved into ct applications in *Fact Files* 4, 30 and 31; now let's look at some common hookups.

Most important precaution when working with ct's is this: *Never open the secondary circuit, or leave it open, when the primary is energized.* Extremely high open-circuit voltages can develop which may destroy insulation and endanger personnel coming in contact with the circuit.

Secondary *burden* is the "load" that instruments or relays connected to the ct impose on it. Burden is usually expressed in volt-amperes or ohms impedance. The burden on a ct affects its accuracy, so don't exceed maximum burden rating specified by the manufacturer.



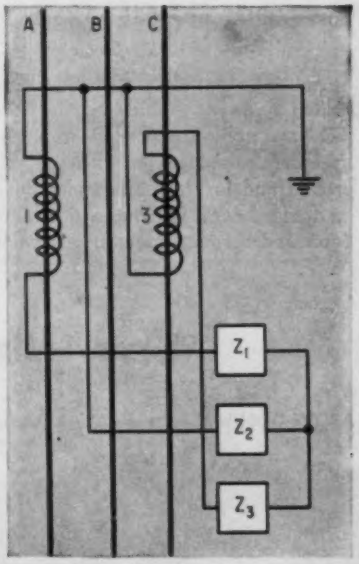
WYE CONNECTION is used on 3-phase 4-wire circuits where three ct's are hooked up. In this case, burden on each transformer usually can be considered burden connected in its phase lead. Example: burden on current transformer No. 1 is burden Z_1



VEE CONNECTION is common for 3-phase 3-wire circuits where only two ct's are used. Find burdens on each with sufficient accuracy using:

$$ct_1 = \sqrt{Z_1^2 + Z_1 Z_2 + Z_2^2}$$

$$ct_3 = \sqrt{Z_3^2 + Z_3 Z_2 + Z_2^2}$$



REVERSED VEE or cross connection is common for metering and relaying. Great accuracy takes vector calculation, but burdens may be found by:

$$ct_1 = \sqrt{Z_1^2 + 3Z_1 Z_2 + 3Z_2^2}$$

$$ct_3 = \sqrt{Z_3^2 + 3Z_3 Z_2 + 3Z_2^2}$$

MARATHON, FLA. plant started up back in 1954. Latest addition in 1959 brings it up to 11,000-kw total installed capacity

PVC pipe cuts diesel-plant maintenance

Salt-water coolant and fuel lines at Florida Keys Electric Co-op still look new after five hard years. Shifting, salty coral made short work of several other piping materials

By T W EDWARDS, Assistant Editor

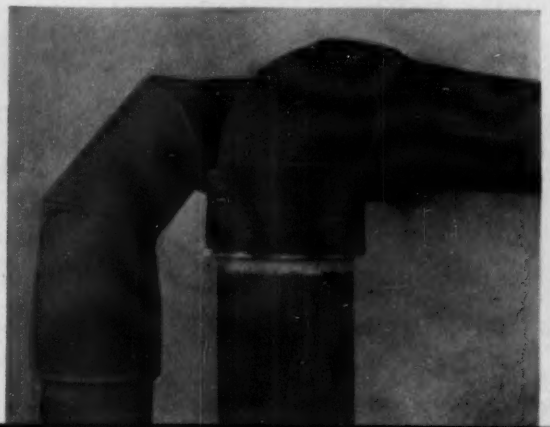
When Florida Keys Electric Cooperative Association started up its new Marathon, Fla. diesel plant in 1954, all fuel lines were coated black iron, and salt-water coolant lines were asbestos cement below ground, admiralty above ground and in plant basement. But the plant was built on dredged coral fill from which salt had not yet leached. Soon underground fuel lines failed because coral backfill had cut pipe coating, exposing steel to effects of salt. Ground shifted, broke some asbestos-cement salt-water coolant lines causing engine-cooling interruption. Corrosive salt air and spray wreaked havoc on above-ground admiralty salt-water lines; lines held out 90 days, then threw in the towel, requiring immediate replacement.

After checking several relatively costly materials in-

Polyvinyl-chloride piping stands up to salty-soil corrosion, ends

ABOVE-GROUND salt-water lines originally were admiralty. These failed; they've used PVC pipe, neoprene-lined valves since

PVC FITTINGS in sizes needed were not available in 1955, so they were made up locally. Compare with the newer cast fitting



cluding stainless steel to meet the severe conditions, Clark Griffin, Plant Engineer, decided to try polyvinyl-chloride pipe (POWER, Sept 1959, pp 65-70) made of Geon vinyls, furnished by B F Goodrich Chemical Co. Frank Miller of Southeast Distributing Co supplied the piping and made up many of the fittings required—at that time, some fittings were not available commercially.

Elbows were made by mitering sections of pipe, then solvent-welded. Couplings and increasers as well as elbow ends were enlarged or reduced as required by heating PVC pipe in hot oil and forcing over proper-size mandrels. When cool, the plastic rehardened and fittings were solvent-welded into piping system. As later additions were made to the plant, they specified commercial fittings whenever available. But even today, Frank Miller makes fittings for 8-, 10- and 12-in. pipe in his own Miami shops. He also fabricates a variety of gate and plug valves, electrical conduit boxes and other piping specialties from PVC pipe and plate.

One year after installation of PVC, cast-iron plug and check valves in salt-water coolant lines failed. They were replaced with neoprene-lined valves of the same type, but the important thing was the condition of the PVC piping—after a year of service, still like new. New lined valves have been trouble-free and show no tendency to deteriorate. A new rotary-gear fuel-unloading pump has recently been installed on the dock, and they've spray-coated it with PVC for protection against salt spray and weather—especially severe in this exposed location.

During unit changeover three years ago, a salt-water-coolant pump was shut down while its particular engine-generator was still on the line. Result: temperature in salt-water lines close to the cooler climbed as high as 230 F. PVC piping, normally good for about 120 to 140 F, softened and sagged. Operators quickly caught the trouble, restoring cold water to the lines, but pipe sag stayed, of course. Since then the sagged system has seen constant service, carrying cold salt-water coolant under rated pressure (about 15 to 20 psi) with no sign of leaks or significant increase in pressure drop. At some convenient time, original configuration can easily be restored by supporting pipe along entire length in wood troughs and reheating to soften. Then when pipe is again straight, it can be cooled and re-set—just as good as new.

Fuel-oil lines for No. 6 and No. 2 oils enter plant underground from outside storage tanks—No. 2 fuel oil is used for startup and shutdown and No. 6 for normal running. When coated black-iron pipe failed, PVC was substituted. Originally the swaged couplings leaked, but they were replaced with machined PVC couplings which have given no trouble.

With these initial operating troubles solved by PVC pipe, Clark Griffin plans to continue use of PVC on salt-water and fuel lines for future units.

PVC at Florida Power and Light

In recent plant additions, Florida P&L of Miami has used PVC pipe and electrical conduit extensively. All underground conduit that's not installed in duct runs is now specified as PVC, to take advantage of lower installed cost as well as high salty-soil-corrosion resistance, resulting in increased life. Drain lines laid in concrete are also PVC for permanence.

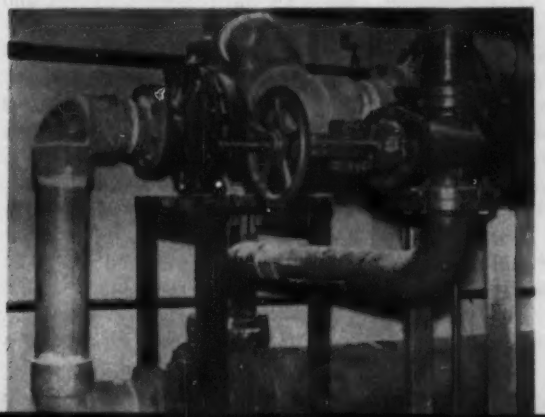
An interesting recent application used PVC piping as support members for cathodic-protection racks. Previously, galvanized-steel supports had to be cathodically protected themselves; asbestos-cement anode racks quickly fouled with algae growth. Inert PVC supports need no protection, and racks can be hosed clean.

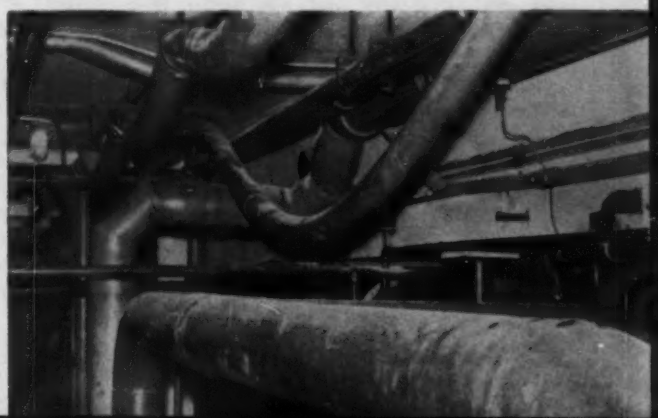
Extensive use of PVC in dust-collection system prolongs life, since pH takes wide swings during run, starting well below 6.5 and ending up at 11. Chemical lines handling phosphate and sulfite for feedwater treatment and 3%-chlorine lines for shock treatment of circulating water are PVC. After five years' service, these lines show no effects of attack.

troubles caused by unleached coral fill in Florida power plants

PVC SALT-WATER LINES are used on heat exchangers for fresh-water engine cooling. No pipe replacement has been needed

ACCIDENTAL HIGH TEMPERATURE caused these PVC lines to soften and sag. But they still carry their rated flow and pressure





OLD AND NEW techniques were compared during plant tests. New experimental product resilver-integrator in one phase replaced one man and three instruments per phase, also improved overall test accuracy. Digital readout, stored until manually reset, reduced possibility of reading error. Bell Telephone time signals plus synchronized clocks meshed generator and turbine test data

Long Island Lighting Company modernizes performance testing as their development program shows . . .

New instruments improve generator load tests

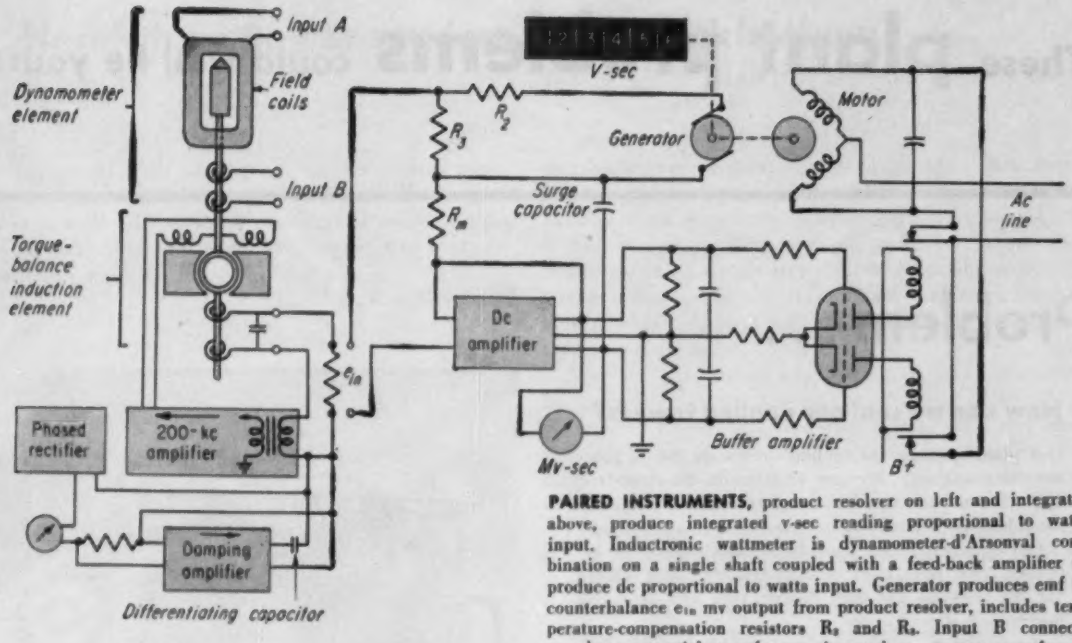
By A R JONES, Long Island Lighting Company, Hicksville, N. Y.

For many years standard method of measuring generator output during heat-rate tests was with indicating wattmeters, a method with many limitations and some distinct disadvantages. But this method embodied enough advantages and was sufficiently accurate to be acceptable, until development of a new method by Long Island Lighting Company and Weston Instruments Div of Daystrom, Inc. Previously, LILCO used three indicating wattmeters for measuring power from a 3-phase 3-wire generator for all heat-rate tests made for both acceptance and routine purposes. The 3-wattmeter method permits incorporating potential-transformer corrections in generator-output calculation.

New method for measuring ac-generator output consists of six units —two units in each phase of a 3-phase 3-wire system. Each set of two units is composed of a product-resolver wattmeter converting ac watts to dc millivolts in a linear relationship—meter registers no error for power factors as low as 0.5. Second unit is a precision dc potential integrator which continuously integrates product-resolver output and displays volt-seconds on a mechanical counter. When we used this combination of product resolver and millivolt-second integrator for our heat-rate tests, we found that when units were properly calibrated and applied, overall accuracy was 0.15%.

For the test all units are warmed up for at least one hour. Following warmup, start-stop button integrator is switched to "stop" and all counters are manually zeroed. We use the Bell Telephone System time signal to give a correct test time period. Signal ties in this part of the test with turbine test data. Synchronized electric clocks are used to back up the audio signal. At test end, integrator is stopped with the switch and counters are read for each phase. We convert volt-seconds to watthours by multiplying volt-seconds by 5/3 for the 150-v range, 5/6 for the 75-v range. Sum of the three converted volt-second readings is then multiplied by the corrected current and potential-transformers ratios to determine mwhr output. Test time interval must be measured very accurately: for this reason we decided to use the Bell Telephone System time signals. Both start and stop audio signals are corrected to the Bell System signals. (For more on LILCO's tests see September issue of POWER.)

Product resolvers and millivolt-second integrators have few errors.



PAIRED INSTRUMENTS, product resolver on left and integrator above, produce integrated v-sec reading proportional to watts input. Inductronic wattmeter is dynamometer-d'Arsonval combination on a single shaft coupled with a feed-back amplifier to produce dc proportional to watts input. Generator produces emf to counterbalance e_{in} mv output from product resolver, includes temperature-compensation resistors R_3 and R_m. Input B connects to phase potential transformer, input A to current transformer

The National Bureau of Standards in Washington found dc-to-ac-transfer accuracy change small enough to be insignificant. The counter can be misread at the test end, but counter readings can be held and verified several times before resetting for the next test. Both units must be stabilized for at least one hour to prevent errors either during calibration or test. Built-in bubble level and mechanism lock minimize tilt error and calibration shift occurring when transporting units to plant.

One advantage of product resolvers is that heat-rate tests can now be made with two men instead of five: three wattmeter readers are not required. Integrally mounting voltmeter and ammeter also saves considerable setting-up time.

Hunting of the generator output during test interval does not affect accuracy of integration. Once started, integrators and product resolvers can be left virtually unattended except for final shutoff. By way of contrast, indicating wattmeters had to be read every minute. So as the test progressed, observational errors increased. With product resolvers, more tests can be run consecutively with no change in expected accuracy.

Disadvantages: Product resolvers originally drifted as much as 0.4% from their first calibration; reversal error also increased. Both of these conditions have been corrected. Instruments are now calibrated before and after all heat-rate tests using two Bureau of Standards certified potentiometers, standard cells, shunt box and volt box in the primary standards room in our meter dept. Initial drift and reversal errors were reduced to less than −0.05% in the laboratory. Since maximum error of the certifying equipment is 0.04% in the laboratory with corrections applied, overall accuracy including external field factor is expected to be about 0.15% in the field. Both the overall-accuracy figure and reversal errors tend to be larger at the lower load values of watts input. However, most of the test data is taken at values sufficiently above this point to allow us to accept the 0.15% accuracy during the heat-rate tests.

To sum up, we believe our new system is less expensive and more accurate than the 3-wattmeter method. At some future time, the product-resolver's output could feed an automatic data logger. The scheme used today is a step in that direction. It's far superior to trying to have test personnel interpolate readings on a wattmeter whose moving system constantly oscillates and whose reading disappears once it is taken, eliminating any possible verification.

Before product resolvers and precision integrators were purchased, overall load-measurement accuracy was thought to be 0.25%. Our experience of comparing the 3-wattmeter method with product resolvers on two different generating units indicates that both methods agree within 0.10% and are probably accurate to within 0.15%. It seems reasonable to assume that product resolvers are more accurate than three wattmeters, especially if the load isn't steady. Increased confidence in load measurement improved calculated heat-rate accuracy from 0.59 to 0.55%. Actually, economic justification for purchase of product resolvers is the marked reduction in overtime costs in our meter dept and the fewer men needed to measure load.

SOURCE: *presentation by S W Lovejoy, A R Jones, Long Island Lighting Co, Instrument Society of America New York Section meeting, April 20, 1960*

These **plant problems** could well be yours...

Problem . . .

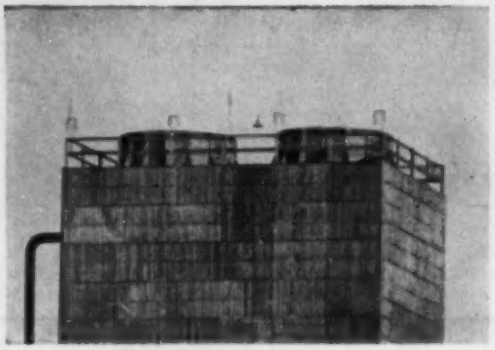
How can we seal our cooling towers?

Our plant operates ten cooling towers for use in process-water cooling. We are situated in Southwestern U.S. Towers are standard steel framework with redwood lumber throughout.

Our problem stems from high maintenance on all timber. We have tried several coatings and sealers for the redwood but they blister, peel and generally lose bond in a short time.

We'd like to know whether anyone has found a reasonable solution to timber-sealant problems?

—*FXM, May* POWER



Solutions . . .

Treat cause, not effect

In trying to seal the redwood in his towers, *FXM* is hoping to prevent the effect, rather than fight the cause of his timber breakdown. Best answer is a good algaecide.

Bacteria, fungi molds and algae use cooling-tower water as a natural habitat and eventually cause failure of the wood. Up until now most tower operators have used chlorine, an oxidizing algaecide, for control.

However, the California Redwood Association, after conducting ten years of tests at Dow Chemical's Freeport, Texas plant, has concluded that chlorine in a cooling tower's circulating water reacts chemically with the wood. It makes the wood more vulnerable to biological attack and causes premature breakdown.

Further tests show: (1) a nonoxidizing algaecide does a better job of killing microorganisms than does chlorine (2) nonoxidizing algaecide inhibits wood rot (3) a nonoxidizing-algaecide treatment usually turns out to be cheaper than the chlorine treatment.

Since *FXM* may have a contamination problem if the cooling-tower water comes in direct contact with his processing system, I would suggest that his chemist contact CRA for selection of the proper algaecide.

J L DOWNING, *Brooklyn, N. Y.*

How about synthetic filler?

I do not believe *FXM* will find a satisfactory solution to his problem as long as he is looking for a *sealer*. Water will always find a way to enter wood, and once it does no paint type of sealant lasts very long. The solution to his problem, if he wants to keep on using wood, will probably be found in one of the wood impregnants—a chemical preservative which enters the pores of the wood under pressure. Since this preservative occupies all available space in the pores there's no place for the water to enter.

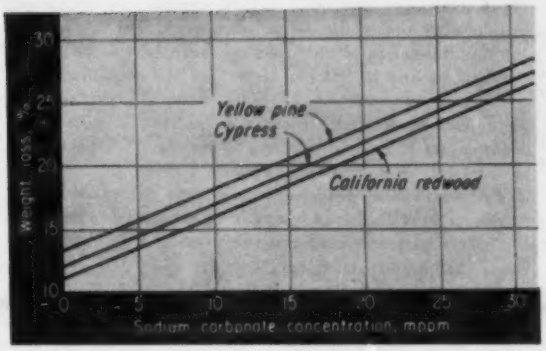
There's another solution to the problem, however.

...Here's how *Power* readers would tackle them

LAWSON STEWART, Associate Editor

We've replaced walls and louvers on our cooling tower with a compressed asbestos type material. Now we no longer have wood and metal problems. I see no reason why we cannot use this material or some other synthetic substitute for other parts of the tower.

J BELUNAS, *Brooklyn, N. Y.*



Check water treatment

Wood deterioration including delignification is usually greatest in nonoperating areas of a cooling tower which are subjected to alternate wetting and drying. Intermittent splashing on parts such as louvers allows salts to precipitate and deposit because of evaporation.

Periodic hosing or other means of removing deposits minimize the adverse effects of salt encrustations. It's all right to hose while the tower is operating.

Before considering tower-wood coatings and sealers, check water properties. Wood deterioration may result from one or more of the following: (1) chemical attack results from high concentration of sodium carbonate or oxidizing agents, causing delignification (2) wood cells rupture because of salt crystallization (3) biological attack leads to wood decay. Deterioration of wood caused by chemical and biological action may be controlled to some extent by water treatment. Various means are available to accomplish this result—look them all over.

High alkalinity and pH values increase rate of failure. Oxidizing agents such as chlorine tend to destroy lignin and other wood constituents. Chlorine residual should be kept below 1.0 ppm. Usually, 0.5 to 1.0 ppm provides adequate algae and slime control.

A pH of 7.0 to 7.5 is preferred, since higher values may cause leaching. If alkalinity is high (pH over 7.5), excessive amounts of chlorine react with the wood lignin. This causes separation of the cellulose fibers.

Concentrations of over 100-ppm sodium carbonate or bicarbonate are frequent sources of trouble. These compounds remove lignin binders from cellulose fibers. Makeup water sometimes contains sodium carbonate, or it may be left by lime, soda-ash softening or sodium-zeolite softening of the water. Plot at left shows weight loss as a function of sodium-carbonate concentration for several woods. Control may use sulfuric acid which converts to sodium sulfate.

Acid feed may be regulated by continuous pH control in proportion to water flow rate or in proportion to tower-water level or constant feed rate if pH and water flow rate are nearly steady. With sulfuric-acid injection, inhibitors may be needed to prevent corrosion of metal components.

Circulating-water temperature also influences rate of failure. Wood temperatures of approximately 88 to 105 F, conducive to this condition, are frequently accompanied by inlet-water temperatures of 103 to 120 F.

Impregnating tower wood with water-soluble compounds is not feasible: they tend to leach out into the circulating water and are lost by blowdown.

Double-diffusion treatment offers minimum loss due to leaching. This procedure involves soaking wood with a chemical solution followed by soaking with a second solution. The chemicals diffuse into the wood and react to form a relatively insoluble precipitate.

Strong copper-sulfate solution followed by a sodium-chromate solution are frequently used. Toxic copper chromate precipitates within the wood. Care in application is necessary since copper salts are corrosive to ferrous metals. A hot 20% solution of copper pentachlorophenate may be used instead of copper sulfate to limit corrosion tendency.

Treating with 6% solution of zinc sulfate and 1% arsenous acid followed by a 6% solution of sodium chromate is an alternate.

Application method varies. With multiunit installations one tower or tower cell may be treated at a time allowing continuity of operation. The unit is removed from service and drained. First chemical solution is sprayed onto the wood and allowed to diffuse and dry. Process is repeated, applying second solution. Keeping fans operating distributes the chemicals well.

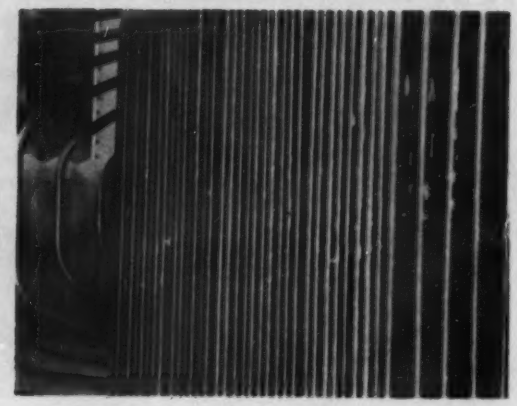
H B WAYNE, *Woodhaven, N. Y.*

continued

Correction

In July 1960 POWER, page 187, (third page of article *Is your boiler-water test program adequate?*) dissolved-oxygen tests by the indigo-carmine method should have been limited to the range of 0 to 50 *ppb* dissolved O_2, not ppm.

Problem . . . Is this boiler safe?

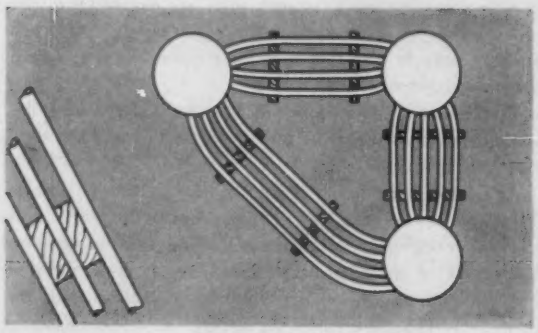


We have been searching for a medium-sized second-hand boiler for our plant, and would like help in deciding the merits of one such unit. The boiler is about ten years old, of Stirling type H, low-head 3-drum design rated at 15,000 lb per hr of 300-psig 480-F steam.

When I inspected the boiler I discovered that tubes at the middle section of the first bank were bent sideways one-half to one in. Drum inspection indicated tubes were in good condition. Present owner states tubes were bent in erection. Insurance-company inspectors frowned on this condition but government inspector says there is no immediate danger.

We would like readers to comment on probable causes of bent tubes, and suggest other tests to check the safety of this steam generator.—*SB, May* POWER

Solutions . . .



Use spacers for tube rolling

When erecting a bent-tube boiler, wood spacers should be inserted between tubes. If they are not used, stresses resulting from expanding in the drums may bend the tubes. Drawing above shows details. Spacer width should be slightly greater than distance between tube tangents. Spacer should require light tapping for removal after erection. Length may be 12 to 15 in.

Number of spacers required is dictated by tube length which is influenced by distance between upper and lower drums. For a low-head boiler one spacer will suffice. Usually drawings furnished by the boiler manufacturer indicate number and location of spacers to be used during erection of boiler-tube banks.

Unit should be hydrostatically tested in accord with ASME Boiler and Pressure Vessel Code, Power Boilers—Section 1. Paragraph P-329 describes requirements. By testing to 1½ times maximum allowable working pressure, *SB* can determine if leaks or structural failure may result. Of particular interest are areas where tubes are expanded in the drum.

It's a good idea to have insurance-company inspector present to witness the test.

H B WAYNE, *Woodhaven, N. Y.*

Used boiler's no bargain

This boiler may be safe against explosion but at the same time it may be very unsafe for the new owner's pocketbook. After 31 years as a boiler inspector, my advice to anyone contemplating buying a used boiler is *DON'T DO IT*. The bare boiler usually represents only about 50% of the cost of boiler when set and ready to go. Foundation, setting, ductwork, etc usually cost as much as the bare boiler delivered to the site. Therefore, even if the boiler costs only 25% as much as a new one, dismantling and rigging costs could bring the

used boiler cost to 90% of a new job. Assuming that you expect to use the boiler for 30 years, used boiler would then be 40 years old—a very old man. The only exception would be a packaged unit. It then should be bought at not more than 25% of the cost of a new job.

One extreme case was a used boiler located where building backed into a narrow alley. To transport it the back wall would have to be destroyed and rebuilt and boiler skidded to a truck. After reaching street it would have to be unloaded, turned ¼ turn, reloaded, hauled 100 miles, be unloaded and turned a half turn. A new boiler (same size) could have been shipped by rail and local truck for 25% less in the customer's yard.

As for boiler's condition, tubes could have become bowed from several causes. Boiler may have been emptied before the setting had cooled enough when preparing the boiler for washout or inspection. A small, localized, very hot fire, such as burning oily rubbish, can cause localized trouble. Tubes may not have been properly anchored against creeping when they were rolled in. It's sometimes necessary to do an excessive amount of rolling. One inspection we did required filling and emptying the boiler 21 times. We would raise pressure, find 10 to 15 tubes weeping at the drum, mark them, empty the boiler, roll the marked tubes, pump up the boiler and then find 10 to 20 new leaks. We spent over two weeks trying to get the boiler tight. It was assumed that the drum had been annealed at too high a temperature and that it took this cold working to get a skin hardness on the tube holes. One inspector that I know came across this same condition. They had to destroy two tube banks, roll in the tube holes and then replace the two banks of tubes.

I personally would not be satisfied to buy the boiler *SB* is inquiring about unless a tube from the middle of the bank was cut out and sawed into pieces about 12-in. long. The pieces should be sawed or shaped lengthways for a good surface inspection and also possibly bend tested. I still say, don't buy a used boiler.

F L Gilmor, *Albany, N. Y.*

Warped tube may be safe

Safety of a boiler can't be determined this way. All conditions must be seen, examined and tested finally by hydrostatic pressure applied internally to boiler to 150% of operating pressure. The deflection you spoke of can easily be done when erecting boilers of this type. If tubes are not held tightly in a straight line when they are rolled in place in tube sheets, shell or drum, they can be twisted. Deflection is not unsafe in this length of tube because the stress is not critical. It only looks bad. You were quite right in noticing it but it can be easily corrected. If you are planning to re-erect this boiler, new tubes can be exchanged at this time. In any case, I would abide by the boiler inspector's wishes.

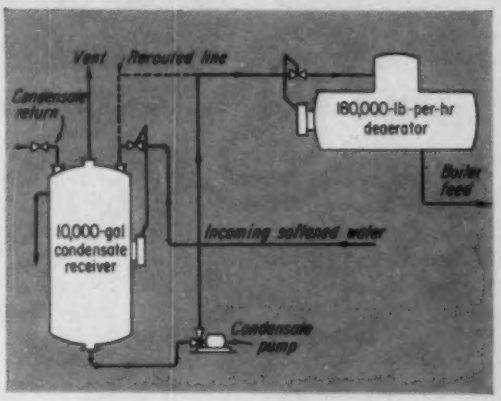
L Harrop, *New Toronto, Canada*

Your August problems

Can we quiet our diesel?

We are thinking about installing an air-cooled diesel standby-power unit in a hospital. When we investigated similar installations we found that because of local and building design we would face a serious noise problem. Noise was comparable to an idling twin-jet aircraft. This unit, coming into service during early morning hours, could create a disturbance, if not hazard, to some patients if installed in or near buildings.

What would be the best type of building construction to house this unit and what insulation should we use? If we know the pitch of the sound, can it be totally cancelled out by some practical method?—*RSB*



How can I stop O_2 corrosion?

Our plant consists of three 60,000-lb boilers with a total condensate-return system. Softened makeup water is now supplied to a condensate receiver controlled by a float valve as indicated. This provides a mixture of condensate and softened water which passes through the deaerator on its return to boilers.

Our condensate receiver has failed. Failure is a result of CO_2 and oxygen corrosion which is accelerated by the condensate softened-water mixture.

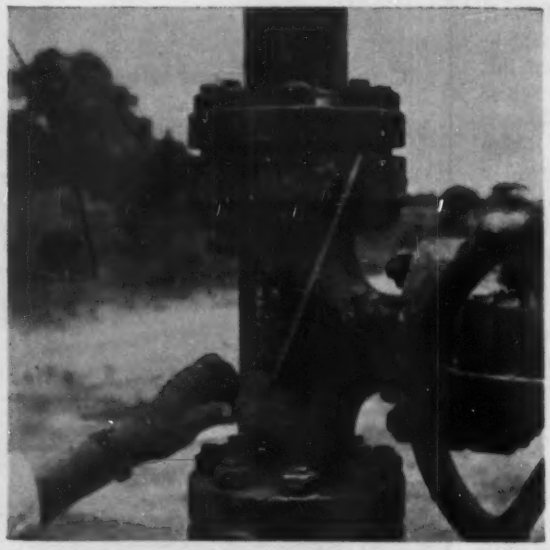
It's my idea to introduce soft water just before entering the deaerator to limit the contact of the mixture to a short length of pipe, shown above.

I'm seeking engineering advice on the soundness of this change in operation.—*GRG*

Sit down right now and answer one or both problems. We'll pay extra for answers with photos or sketches

Timely practical ideas

STEVE ELONKA, Associate Editor

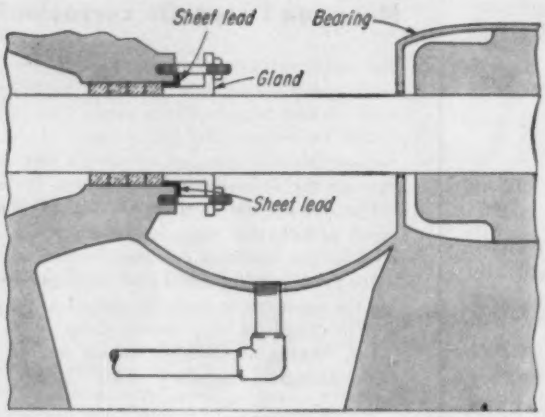


Modeling clay holds thermometer in place

Find out the temperature of fluids inside your lines to determine loss in transit by fastening a thermometer to the pipe with modeling clay, photo. Clay can be purchased wherever schoolroom supplies are sold, can be used over and over. Ordinary clay has a high melting point and stays securely in place on very hot lines.

You may have to wrap a cloth around the pipe over the thermometer if you leave the setup unattended. This method is used by Shell Oil Co to get the flowing temperature of gas inside their pipelines, as photo shows.

H Hess, *Houston, Texas*



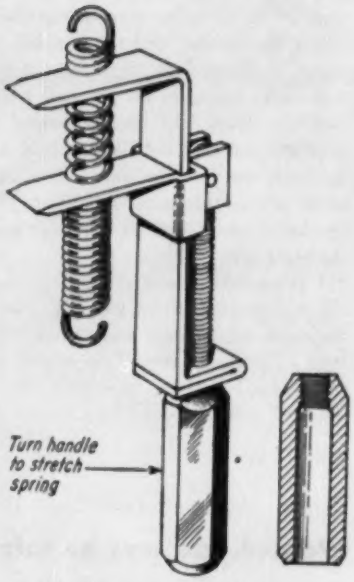
Sheet-lead filler cured our bearing woes

Our problem was preventing water from getting into the auxiliary-feed pump's inboard shaft bearing. Pump had been overhauled and repacked but water still poured out. Bearing filled up, oil was washed out and eventually the bearing was ruined. We repacked the gland to no avail.

We decided that we must have chipped the stuffing-box bore with a hammer when we made a new gasket. Now we had to stop the leakage without shutting down the pump.

We cut a piece of 1/16-in. sheet lead in shape of gland. Then we cut a hole a half thickness of packing larger than shaft. After removing the last ring of packing, we used gland follower to form sheet lead into the gland. Then last ring of packing was squeezed back into place. That folded the sheet lead back against the gland face, sketch. Now water drip is at a minimum and not a drop gets into the bearing to do any damage.

B Zetchus, *Temiskaming, Que.*



You'll find this spring spreader a handy tool

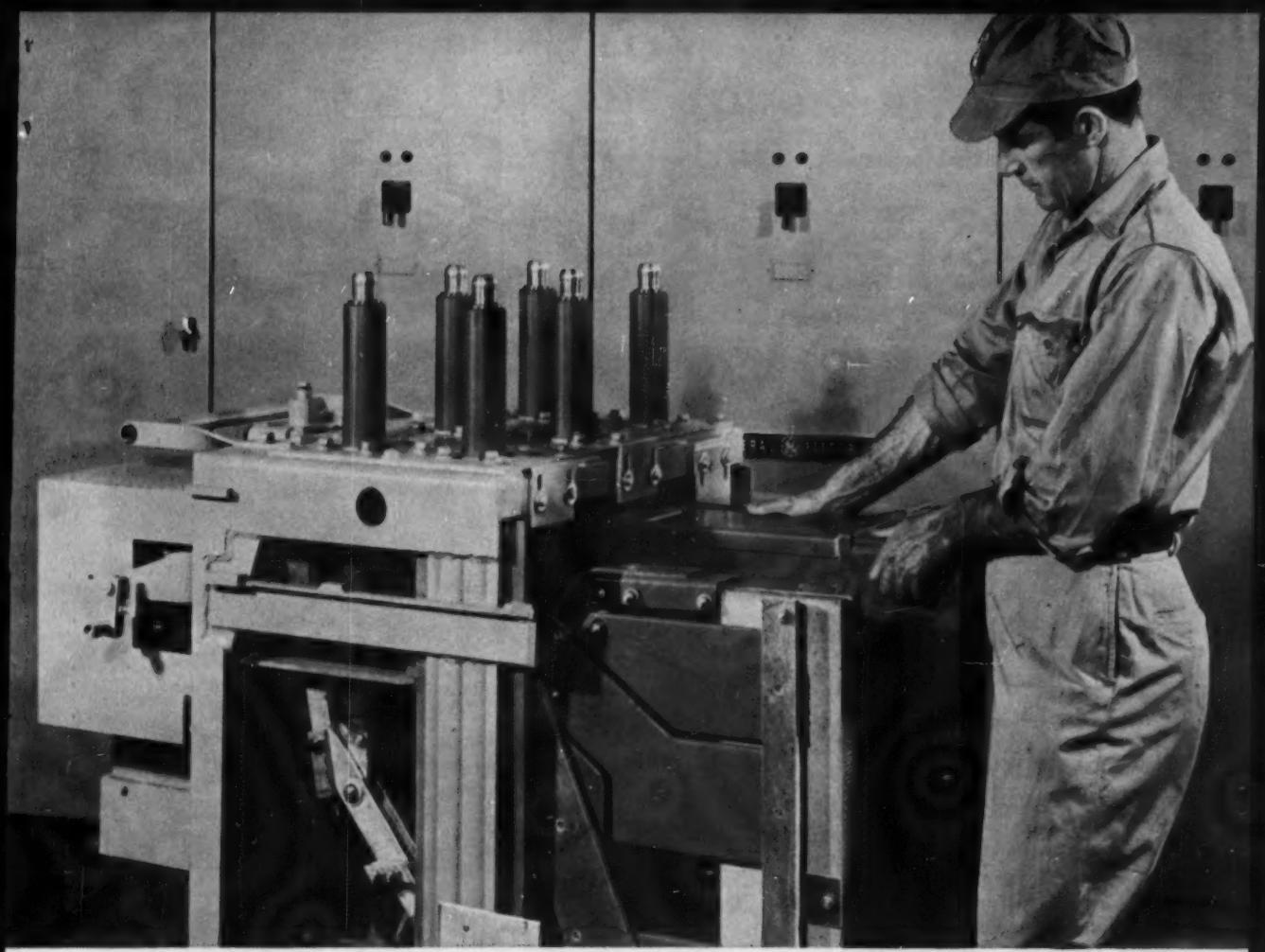
Here's a simple shop-made tool well worth the time it takes to rig it up. Easiest way is to use flat stock. First bend the long fixed jaw, then form the movable jaw around a flat piece of stock. Don't form jaw at end of fixed jaw until movable jaw is put on. Make a hex handle tapped to fit a flattened end screw, sketch.

C H Willey, *Penacook, N. H.*

continued

Change hats with your maintenance man, he will demonstrate . . .

FAST MAINTENANCE



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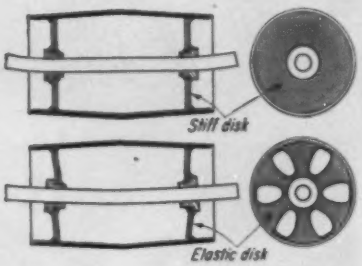
you can obtain background reading material for most subjects connected with energy-systems engineering at a cost of one dollar or less? Suggested reading material for the student or trainee in our field is listed after each of the 19 chapters in the new *Standard Plant Operator's Questions and Answers*, Vol I and II, published by McGraw-Hill Book Co, New York 36, N. Y., in the fall of 1959.



Here's how we improved our conveyor pulley

Head-and-tail pulley shafts on some of our coal-handling equipment deflected and gyrated under occasional peak loads, shown exaggerated in top sketch. Operating shafts under these conditions did not affect the self-aligning shaft bearings, but had a tendency to wear and bellmouth hub bores of the welded-steel pulleys. As a result, pulleys came loose and shifted on their shafts, no matter how tightly we secured them. Operating with pulleys out of line caused the conveyor belt to wear rapidly.

We cut openings in the pulley disks with a cutting torch, lower sketch. Metal we removed didn't weaken the disks, but made them flexible, so disks can flex and hubs gyrate with the shaft as it deflects.

Now, with a less restrained shaft and elastic gyration of the hubs, bore wear is prevented. Pulleys remain tight and in line on the shafts, improving belt performance by keeping the belt in its natural position.

E Wittmann, *Villas, N. J.*

What would you have done?

Our glass factory works around the clock, with no interruption. One of our large production machines has a long 2-in.-dia lead screw working through a bronze bushing. The screw has four separate threads, each 90 deg from the next. Trouble was that bushing threads thinned after constant use, then stripped out of the bushing. Threads on the screw were OK.

We found that the pitch of each thread was 1½ in. None of our engine lathes could handle that pitch, nor any lathe in our locality. Our plant is miles from nowhere. What to do?

We needed that machine; downtime was costing money. So we removed the lead screw and coated it with a thick layer of oil-and-graphite paste. Then we heated the screw to 500 or 600 F and used it as a core in a sand-casting box. We cast a bronze bushing around the lead screw. After the bushing cooled, it was easy to screw the lead screw out of it, and we had perfect threads. A new machined bushing could not have been better. What would *you* have done?

B W Hausman, *Wallaceburg, Ont.*

My favorite gripe

To blow down the water column of our boiler safely, we installed a low-water cutout bypass button. With this arrangement the operator *had* to keep one hand on the blowdown valve and the other on his button—so we thought. But along comes an operator who probably was expelled from kindergarten for not shaving, and rigs up a locking arrangement to keep the button depressed so he won't have to hold it in. But one day he forgot to release the button and went back to his funny papers. You know what happened!

Why is it that a plant engineer spends hours and sometimes days designing and building some device to make a plant safer, then after it's all rigged up and works perfectly something like this happens?

T Mullin, *Seattle, Wash.*

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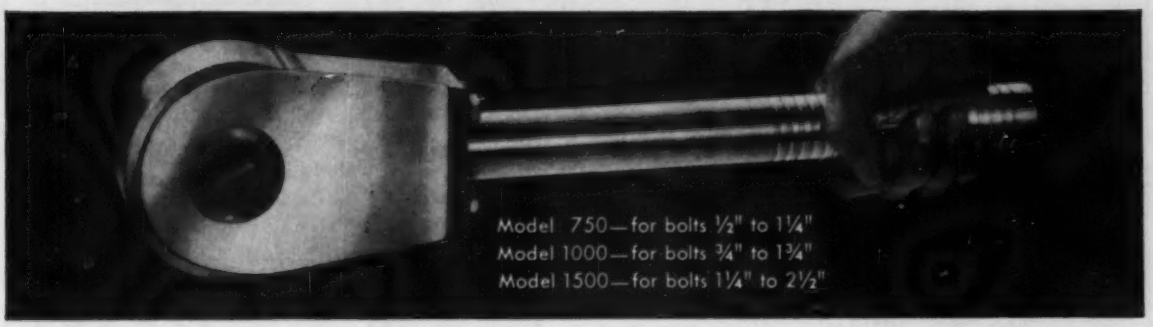

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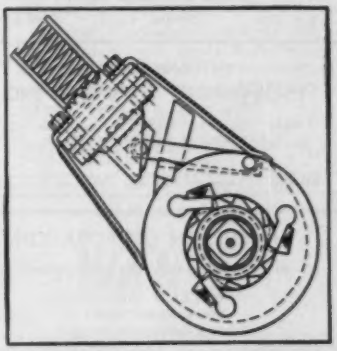

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ANSWER
to Worthington Hidden Value Puzzle

The fictitious "hidden value" on the back cover is, of course, the "Articulated Connecting Rod." This design is found only on light duty compressors with single acting cylinders.

The true Worthington connecting rod construction is shown above. Each rod is directly mounted on the main crankshaft, giving greatest bearing area and stronger linkage. There are fewer parts in all, maintenance is simpler and lubrication is less complex. Worthington Corporation.

WANTED

WE PAY $ CASH $ FOR
Electric Motors • Starters • Transformers
Circuit Breakers — Electric Supplies
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AVAILABLE: NEW MOTORS
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AJAX ELECTRIC MOTOR CORP.

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OR . . . something you don't want— that other readers can use—
Advertise it in the
SEARCHLIGHT SECTION

CHECK WITH WAGNER FIRST!

Thousands of new and "Certified Rebuilt" Motors & Generators in stock—up to 1000 H.P.

OUR 54th YEAR

A. C. MOTORS—60 CYCLE

HP	Mfr.	Type	Volts	Speed
800	Whse. (2)	Sq. Cage	2300	1800
750	G.E.	Slipring	2300	514
600	G.E.	Synch.	440	900
600	Elliott (2)	Sq. Cage	2300	900
500	Al. Ch. 3 brg.	Slipring	440	514
500	Allis Ch.	Slipring	2300/440	600
500	Whse.	Sq. Cage	2300	514
400	Marathon (2)	Sq. Cage	2300	3000
400	G.E.	Slipring	2300	514
400	El. Machy.	Synch.	2300/4000	400
350	El. Machy.	Synch.	2300	900
350	Dr. Boveri b.b.	Sq. Cage	4300/440	720
350	G.E.	Sq. Cage	2300	1800
350	Allis Ch.	Slipring	2300/4000	600
300	G.E.	Slipring	220/440	514
250	G.E.	Sq. Cage	2300/440	1200
250	G.E.	Sq. Cage	2300/440	450
250	Gen. Elec.	Sq. Cage	440	3600
250	G.E. TEFC	Sq. Cage	440	1200
250	Whse.	Sq. Cage	2300/440	600
250	Whse. (4)	Slipring	2300/440	600
200	Gen. Elec.	Synch.	550/440	400
200	G.E. b.b.	Sq. Cage	220/440	720
200	G.E.	Slipring	220/440	450
200	G.E.	Slipring	440	600
200	G.E.	Slipring	2300	900
200	Reliance b.b.	Sq. Cage	220/440	1800
200	Allis Ch.	Slipring	2300/440	720
150	G.E. TEFC (2)	Sq. Cage	220/440	900
150	Whse. XP	Sq. Cage	440	3600
150	G.E. (4)	Slipring	2300/440	600
150	G.E. (2)	Sq. Cage	2300/440	1800
150	Whse.	Slipring	220/440	1200
150	Whse.	Slipring	2300	450
125	Whse. b.b.	Sq. Cage	220/440	900
125	A.C. TEFC	Sq. Cage	220/440	1800
125	El. Machy. (2)	Synch.	220/440	400
125	G.E. TEFC	Sq. Cage	2300	3600
125	Al. Ch. TEFC	Sq. Cage	220/440	600
125	G.E. (2)	Slipring	220/440	514
100	Allis Ch.	Slipring	2300/440	600
100	Al. Ch. TEFC	Sq. Cage	2300	1800
75	G.E. b.b. (8)	Sq. Cage	220/440	1200

D. C. GENERATORS

KW	Mfr.	Type	Volts	Speed
300	Gen. Elec.	CY-221	250/350	1200
200	Gen. Elec.	HC	250	1450
100	Delco b.b.	Into	120/240	1200
75	Whse. b.b.	BK	250	1800
75	Allis Ch. b.b.	EB-146L	125	1500
60	Ideal	D	125	1150
60	G.E. b.b.	CD	600	1750
50	G.E. (2)	CD-1120	250	1200

D. C. MOTORS

HP	Mfr.	Type	Volts	Speed
250	Cr. Wh.	101-H	230	1150
200	G.E. (2)	RC-3A	230	1150
200	Whse. b.b.	BK	250	287/575
150	Rel. TEFC b.b.	2350-P	230	850
150	Whse.	BK-210	230	220/1000
125	G.E.	CD-173	230	575/1150
100	Elliott b.b. T.E.	JH-FE	230	1150
100	El. Dyn. b.b. (2)	36-S	230	450/1200
75/100	Whse.	BK-191	230	300/900
60	G.E. TEFC b.b.	CD-135	230	1150
50	G.E.	BF-16	230	250/1000
50	Century new	DN-514	230	1150/1750
40/50	Reliance b.b.	310-T	230	600/1800

MOTOR-GENERATOR SETS

KW	Mfr.	Input V	Output V
600	Allis Ch.	440 AC	250 DC
300	G.E.	440 AC	250/550 DC
200	Allis Ch. (2)	440 AC	250 DC
200	Whse. synch.	220/440 AC	85 DC
200	Gen. Elec.*	220/440 AC	125 DC
125	Gen. Elec.*	2300/4000 AC	250 DC
125	Whse.	220/440 AC	250 DC
100	Delco b.b.	220/440 AC	120/240 DC
80	Star b.b. Synch.	220/440 AC	250 DC
75	Whse. Synch.	220/440 AC	250 DC
60	Ideal	220/440 AC	125 DC
50	Whse. synch.	220/440 AC	250 DC
20	G.E. (2)	220/440 AC	125 DC

Arthur Wagner Co. Certified

MQ nrpe 6-7409

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TRANSFORMERS

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3—2500 KVA G-E 69000—2300Y
3—2500 KVA G-E 69000—2400/4160Y
3—2500 KVA G-E 69000—7200/12470Y
4—2500 KVA W-H 34500—2400/4800
3—1500 KVA G-E 69000—2300Y
3—1500 KVA G-E 69000—2400/4160Y
3—1500 KVA G-E 69000—7200/12470Y

THE ELECTRIC SERVICE CO., 5322 Hetzel St., Cincinnati 27 Ohio

"America's Exclusive Independent Transformer Service Shop"

Circle 503 on Reader Service Card

NEW G.E. A.C. MOTORS

FOR HYDRAULIC PUMPS OR HYDRAULIC DRIVEN DECK MACHINERY OR CRANES

New, as removed from U.S. Naval vessel Hawaii.

ALL A.C. 440/3/60

10 HP Continuous — 40 HP intermittent ½ hour. High slip, high torque, induction type KR. 2 available.

10 HP Continuous—40 HP intermittent ½ hour—1040/520 RPM. 1 available. (The above two motors have magnetic brakes.)

15 HP Continuous—60 HP intermittent ½ hour. 1770 RPM—type KF.

20 HP Continuous—1770 RPM—type KF.

40 HP Continuous — wound rotor—440/3/60 — 635 RPM Type M. 1 available.

18¾ HP Continuous—75 HP intermittent ½ hour—1775 RPM—2 available—type KF.

200 HP Continuous—squirrel cage—440/3/60—1775 RPM—type KF, with brake—2 avail.

THE BOSTON METALS CO.

313 E. Baltimore St., Baltimore 2, Md.

ELGIN 5-5050 — LEXINGTON 9-1900

Circle 504 on Reader Service Card

POWER EQUIPMENT

5500 KW, G.E. Non C. Turbo-Gen. 3/50, 2300 V, 3000 RPM 600 PSIG 650°TT, 150 PSIG Exh.

5000 KW, West. Non C. Turbo-Gen. 3/60, 2300 V, 3600 RPM 850 PSIG 850°TT, 110 PSIG Exh.

1500 KW, G.E. Cond. Extr. Turbo-Gen. 3/60, 2400 V, 3600 RPM 200/400 PSIG, 750°TT, 15# Extr.

1000 KW, Worth.-Moore, Cond. Extr. Turbine, 3/60, 245/490V, 3600 RPM 130-300 PSIG, 10# Extr.

300 KW, G.M. 8-268A, Diesel Units (2) 3 ph. 60 cycle, 480 V. 1200 RPM.

500 KW, .8 P.F. West. 3/60, 240/480V 300 RPM, Gen. direct conn. to Ames Vertial Uniflow Engine.

BREW, WOLTMAN

& COMPANY, INC.

50 CHURCH ST., N.Y. 7, N.Y.

Circle 505 on Reader Service Card

CONVERSION & POWER EQUIPMENT

M-G SETS—3 Ph. 60 Cy.

Qu.	KW	Make	RPM	DC Volts	AC Volts
1	4000/4800	G.E. (SU)	450	250/300	2300/4000
1	2500	Whse. (SU)	720	600	2300/4000
1	1750/2100	G.E.	514	250/300	2300/4600
1	2000	G.E.	514	600	2300/4000
1	1500	G.E.	720	600	6600/13200
1	1000	Cr.-Wh.	720	100	2300/4160
1	1250	Whse.	720	600	2300/4160
1	1000	G.E.	900	600	2300/4000
1	1000	G.E.	720	250	2300/4160
1	1000	G.E.	900	250	4000/6900
1	800	G.E.	900	125/250	440
1	500	G.E.	900	250	2300/4000
1	500	G.E. (new)	1200	300	2300
1	400	C.W. (SU)	1200	125/250	2300
1	350	G.E.	900	125	440/4160
3	300	G.E.	1200	250	2300
1	300	Whse.	1200	600	2300/4160
1	200	G.E.	1200	250/275	440
1	200	G.E.	1200	250/275	2300/4160

MERCURY ARC RECTIFIERS

Qu	KW	Make	Type	DC Volts	AC Volts
2	150	G.E.	HP 30	245	208
1	150	G.E.	6RP	275	2300/4160

FREQUENCY CHANGER SETS

Qu.	KW	Make	Freq.	Voltages
1	5000	G.E.	60/50/60	11000/6600
1	2500	G.E.	25/62½	2300/2300

TRANSFORMERS

Qu.	KVA	Make	Type	Ph.	Voltages
3	3333	Whse.	OISC	1	13800Y/2300
1	3000	A.C.	OISC	3	34500Y/2300
3	1000	G.E.	OISC	1	13800Y/480
3	833	A.C.	OISC		13200Y/2300

TURBO GENERATORS

Qu.	KW	Make	Description
1	1500	G.E.	Non Cond. 125#/5-15# B.P. 2300V.
1	2000	G.E.	Cond. 400#-750° 2400/4160Y.
1	4000	G.E.	Cond. 400#-750° 2400/4160Y.

A.C. MOTORS — 3 Ph. 60 Cy. Slip Ring

Qu.	HP	Make	Type	Volts	Speed
1	1750	G.E.	M-9788	4000/2400	1200
1	800	Whse.	CW	550	1775
1	350	G.E.	MT-428	2200	450
1	600	Whse.	CWP-332D-15	440	1775
1	600	Whse.	CW	440	850
1	350	Whse.	CW	440	225
	(Unused)				

SQUIRREL CAGE

1	550/275	Whse.	CR-1115	2200	450/900
1	500	G.E.	FT-509Y	2200	3600
2	300	Whse.	CWP-583H	440	3600
4	500	Whse.	CR-1215	2200	900
2	450	Elliott	3910	2300	1185
1	400	Whse.	CR-7151 4000/6600		3600
1	300	Whse.	CR-1002E	2300	600
1	300	G.E.	KT-659A	2200	1775

SYNCHRONOUS

1	7000	G.E.	ATI	2200/6600	600
1	3500	G.E.	TS-6487	2200/4000	360
2	1750	G.E.	ATI	2200	3600
1	333	G.E.	ATI	440	1800

RE-NU-BILT BY

BELYEA COMPANY, INC.

43 Howell St., Jersey City 6, N. J.

Tel: OLDFIELD 3-3334

Circle 506 on Reader Service Card

DIESEL ENGINE GENERATOR UNIT

575 HP, 600 RPM, Worthington Type DH-6 Diesel engine direct connected to 500 KVA—400 KW, 80% PF, 600 RPM, 3 phase 60 cycle, 240/139 volts Electric Machinery synchronous generator complete and equipped with exciter, switchboard with instruments, attached and unattached auxiliaries to the engine. Slightly used—practically new. Immediate delivery.

UTILITIES MACHINERY CORPORATION

1965 East Sixth Street, Cleveland 14, O.

Circle 507 on Reader Service Card

COMPLETE MODERN 400 LB. POWER PLANT

3750 KVA Westinghouse Turbine Generator — 2 600 HP Combustion Engineering Boilers, 450 PSIG W. P. Turbine is 400 PSIG 750° FTT with surface condenser and auxiliaries. Generator 3/60 6900/4160 with Exciter and Switchboard. Surface Condenser and all auxiliaries.

This plant is complete in all respects and can be inspected as originally installed. Photographs, prints and specifications available

Other turbine Generators

1-1500 KW Westinghouse	600# 750° Non-Cond. 150# BP 2400V
1-2000 KW GE	600# 750° Non-Cond. 150# BP 4160V/6600V
2-3000 KW GE	600# 750° Non-Cond. 150# BP 2400/4160V
1-2500 KW Allis Chalmers	400# Autext 150° Non-Cond. 30# 480V
1-2500 KW Westinghouse	125# Non-Cond. 10# BP 2300V
1-2500 KW GE	400# 750° Autext 25# Condensing 600V

Cable Address: CHASWEAVER

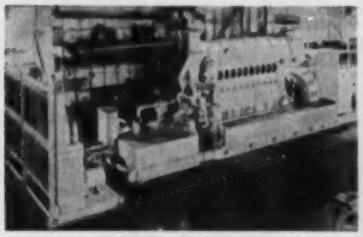
CHARLES WEAVER, INC.

19701 JAMES COUZENS HIGHWAY
DETROIT 35, MICHIGAN

Telephone: BRoadway 3-1900

Circle 508 on Reader Service Card

Portable diesel engine generator for peaking power



A 1000 kw portable power plant will supplement existing steam plant of the city of Norwalk, Ohio. Remanufactured by A. G. Schoonmaker Co., the portable plant with Fairbanks-Morse model 38D819 ten cylinder diesel engine was considered by city engineers the most efficient and economical for peaking purposes. Remanufactured diesel generators from 100 kw to 1000 kw are available for purchase, on short term lease, long term lease or on a lease-option arrangement for installation anywhere in the world.

A. G. SCHOONMAKER COMPANY, Inc.

Foot of Spring St., Sausalito, Calif.
EDgewater 2-1490

30 Church Street, New York 7, N. Y.
Digby 9-4350

Circle 509 on Reader Service Card

ELECTRICAL POWER EQUIPMENT

SLIP RING MOTORS

3 ph 60 cy 220 or 440 volts

HP	RPM	MAKE	TYPE
1500	514*	Al.-Ch.	Mill Type
1200	360*	Al.-Ch.	Mill Type
900	168*	Al.-Ch.	Mill Type
600	1800*	Gen. Elec.	M-6345R, Dppf. Now
500	1200	Gen. Elec.	M-6345X, Dppf.

*2200 volts or higher

SQUIRREL CAGE MOTORS

3 ph. 60 cy. 220 or 440 volts
(*2200 volts or higher)

HP	RPM	MAKE	TYPE
1250	3600*	Al.-Ch.	ANX
800	1800	West.	CS34C
600	600*	West.	CS-44-C15 Dppf (2)
500	1200	G.E.	I-K
400	1800*	L. Allis	BB. Sppf.
400	1800	West.	BB. Dppf.

MOTOR GENERATOR SETS

KW	Make	Motor A.C.V.	Generator D.C.V.
1000	West.	4160	230
600	G.E. (3 unit)	2300/440syn.	125/250
500	West.	2300/440syn.	125/250
400	Al.-Ch.	2300/440syn.	125/250
300	West.	2300/440syn.	250
200	Rel.	2300/440syn. TB	500
200	G.E.	2300/440syn. TB	250/275

TRANSFORMERS

Special Offer — Like New

3—1250 KVA Allis Chalmers Class OA Oil filled 3ϕ ph 60 cy 34,000 Volt primary, 480 volt secondary with taps, manufactured 1955.

Write for current complete stock lists on electrical power equipment you need or send your list of surplus and used equipment for our offer.

Phone CAnal 6-2900

CHICAGO Electric Co.

1320 W. CERMAK ROAD • CHICAGO 8, ILL.

Circle 510 on Reader Service Card

NEW EQUIPMENT FROM THE UNCOMPLETED

BATTLESHIP U. S. S. KENTUCKY

Installed but never used
Built of finest materials

WESTINGHOUSE 1250 K.W. TURBO-GENERATORS

(4)—Westinghouse—440/3/60—850°—340 lbs. working pressure. Complete with condensers, circulating pumps, etc.

BOILERS

7 B&W EXPRESS TYPE

Design pressure 634# — operating pressure 565# — temp. 850°F. Oil fired — separately fired superheaters. Capacity: 210,000 lb. steam/hr. ideal for testing where large quantities of steam are required, giving excellent control from separately fired superheaters. Can be converted for #2 oil and natural gas. Fully automatic.

LARGE DEAERATING FEED HEATERS

Monel construction—spray type—capacity 480,000 lbs./hr.—vent condenser—single pass—heating surface 174 sq. ft.—all Monel construction.

GE HIGH AND LOW PRESSURE MAIN PROPELLING TURBINES

Will sell separately for testing, wind tunnel or similar work. (2) high pressure—24,400 HP—12 impuse stages—4909 RPM—working pressure 540 lbs.—825°F. (2) low pressure—28,600 HP — 3913 RPM — working pressure 49 lbs. steam—424°F—2-6 stages of impulse.

THE BOSTON METALS CO.
313 E. Baltimore St., Baltimore 2, Md.
ELGIN 5-5050 — LEXINGTON 9-1900

Circle 511 on Reader Service Card

UNUSED—ASSEMBLED—NEW

IN ORIGINAL MANUFACTURER'S PACKING CRATES

BOILERS (Package type)

B&W—80,000 lbs./hr.—475 psig., 740°TTF, oil fired (shipped intact as one integral unit)
B&W—122,500 lbs./hr.—635 psig., 850°TTF, oil fired (unassembled)
B&W—133,800 lbs./hr.—634 psig., 850°TTF, oil fired (unassembled)
B&W—153,000 lbs./hr.—635 psig., 850°TTF, oil fired unassembled, new—unused

TURBOGENERATORS

4800 KW GE Turbine—Gen Set, Cond 410psi, 725°TTF, 28.5 Hg exh, 3/93.3/2700V PF 1.0—New
1800 KW GE Turbine—Gen Set, Cond 410psi, 725°TTF, 28.5 Hg exh, 3/60/1735 V PF 0.8—New
1500 KW Westinghouse—Gen Set, Non Cond 400psi, 3/60/480V PF 0.8
1000 KW GE Turbine—Gen Set, Cond 200psi, 600°TTF, 28.5 Hg exh, 3/60/2400V PF 0.8

STEAM TURBINES

1000 SHP GE Cruising Cross Compound, 525psi, 825°TTF, 81psi exh, 10,119/350 RPM with Falk reduction gears—New
3000 SHP GE HP Main propulsion turbine 410psi, 9040RPM, 725°TTF } 1 Set—New
3000 SHP GE—LP Main propulsion turbine 40psi, 9040RPM
11,550 SHP GE HP 12 Stage Cross compound turbine 525 psig, 825°TTF 5870RPM } 1 Set—New
13,450 SHP GE LP 48psig, 4714RPM with Westgh speed decreaser gear assy.
294 HP Worthington-Moore, Non-Cond. Form ZSR, 310psig, 650°TTF, 2psi-exh, 3560RPM
250 HP Sturtevant non-condensing Turbine—575psi, New

PUMPS, CENTRIFUGAL (Motor driven)

283 GPM @ 375'TDH, Ingersoll Rand—2GT, w/60HP 3525RPM 3/60/220/440V (Used)
275 GPM @ 635'TDH, Ingersoll Rand—2GT, w/75HP 3525RPM 2/60/2300V (Used)
200 GPM @ 1300'TDH, Ingersoll Rand—½CNTA, w/Base, Motor optional

PUMPS, CENTRIFUGAL (Turbine driven)

480 GPM @ 750psi discharge, Worthington, w/350HP turbine, 575psi, 4900RPM—New

BLOWERS, TURBO-CENTRIFUGAL

10,000 CFM @ 17"WC, Westinghouse, Vaneaxial, w/Turbine, 82.5HP, 375psi, 10psi—exh, 4625RPM—New
24,000 CFM @ 26"WC, Sturtevant Co, Rexvane, w/Turbine, 191HP, 400 psi, 10psi—exh, 3525RPM—New
43,000/50,000 CFM @ 8"/11"WC, Sturtevant, Turbovane, w/Turbine 86/141HP, 400psi, 10psi —exh, 4980/5870RPM—New

WABASH POWER EQUIPMENT CO.

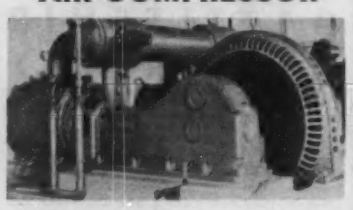
9750 SKOKIE BLVD., CHICAGO, ILLINOIS—TEL. OR 3-8118

3757 Wilshire Blvd. Los Angeles 5, Cal. | 1684 Hudson San Francisco, Cal. | 730 Dearborn Seattle, Washington

Circle 512 on Reader Service Card

LARGE CAPACITY

AIR COMPRESSOR



700 HP—WORTHINGTON—3468 CFM

125 PSI — LATE STYLE

Inspect on Original Foundation

EARL E. KNOX CO.

1109 BACON ST. ERIE PA.

GL 6-7037

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TRANSFORMERS

1—10667 kva G.E. 3/60/88000/11500
1— 9667 kva Westinghouse 3/60/115,000Y/13750
1— 6000 kva G.E. 3/60000/2400/4160Y
1— 2000 kva Nia. Askarel, 3/13800/4160Y/2400 new
1—3000/5250 kva, GE 1/60/115,000 pri. 11,500 sec. unused
1— 300 kva Pcnna. 3/60/2400/4800 pri. 120/208Y Sec.
3— 1500 kva Wagner, 1/60 cy. 6900—2400/4160Y
1— 1000 kva Standard, 1/44000/6900
1— 4000 kva Standard, 1/69000/4160Y/2400
1— 1000 kva Standard, 1/34400/480
1— 833 Allis Chalmers 1/60/12,000-480
1— 750 kva. GE 1/60/13,800 pri. 480 sec.
1— 500 kva. GE 1/60/11,500 pri. 480 sec.
1— 500 kva. dry Standard. 1 ph. 60 cy. 2400/4160Y pri 480 Sec.
3— 333 kva G.E. 13200/480
1— 200 kva dry Kuhlman, 1 ph. 60 cy. 2400 pri. 480 sec.
3— 150 kva. Uptegraff 1/60/4800 pri. 480 sec.
1— 250 kva. dry Standard. 1/60/2400/4160Y pri. 240/480 sec.
3— 150 kva G.E. 1/60/2400/4160Y pri. 240/480 Sec.
3— 100 kva. Uptegraff 1/60/2400/4160Y pri. 240/480 sec.
3— 100 kva. GE H.K. 1/60/4800/8320Y pri. 480 sec.
3— 100 kva G.E., 2400/4160Y—120x240
3— 75 kva G.E., 2400/4160Y—120x240
3— 50 kva WEST CRP. 4160/7200Y, 120/240

ERIE ELECTRIC CO., INC.
28 Mechanic St. Buffalo 2, N. Y.

Circle 514 on Reader Service Card

HERCULES DIESEL ENGINE GENERATOR SETS

NEW — 1959 — Portable — Skid Mounted — 6 Cylinder 1800 RPM 0.8 P.F.

30—K.W.—120/208 240/440 Volts—3 phase —60 cycle, 4-Wire with Neutral for single phase. Enclosed—Designed for outdoor use. Heated for fast winter starting. Complete with Switchboard & Engine Panel. Automatic Voltage Regulation. Inspection under power invited. Immediate Shipment from Phila. or Miami, Fla.

Sale or Rent

T. B. MacCABE CO.

4314 Clarissa St. — Philadelphia 40, Pa.
Phone — DAvenport 4-8300

Circle 515 on Reader Service Card

SPECIAL OFFERING!

3 NEW UNUSED 850 KW DIESEL GENERATOR SETS

installed but never run

ENGINE:

Fairbanks-Morse model 38D8 ⅛ — bore & stroke 8⅛ x 10—@ 720 RPM.

GENERATOR:

Complete—drip-proof enclosure—850 KW 440/3/60 @ 720 RPM—80% P.F.—with direct-connected 7½ KW exciter.

The above units are complete with filters, strainers, heat exchangers, mufflers, air intake silencers, etc., and are complete in every detail. They are mounted on a common pre-fab sub-base, and have the latest deadfront switchgear, distribution & voltage regulators. These units are perfect in every respect & have been carefully preserved by the U.S.N. Can be seen in our warehouse or aboard the "Hawaii."

THE BOSTON METALS CO.

313 E. Baltimore St., Baltimore 2, Md.
ELGIN 5-5050 — LEXINGTON 9-1900

Circle 516 on Reader Service Card

FOR SALE

675 HP COOPER-BESSEMER DUAL FUEL DIESEL-GAS. 500 KW. 3/60/2300V. COMPLETE.

1275 HP COOPER-BESSEMER DUAL FUEL DIESEL-GAS. 900 KW. 3/60/2300 V. NEW 1953.

3000 KW GE CURTIS CONDENSING TURBO. 400# ISP. 3/60/2300 VOLTS. BUILT 1930. COMPLETE. EXCELLENT.

WHISLER EQUIPMENT CO.

1908 Railway Exchange Building
St. Louis 1, Mo.

Circle 517 on Reader Service Card

FOR SALE

14 NEW TURBINES

4 horizontal, 10 vertical, Westinghouse
Driving forced draft blowers—capacities ranging from 29000 to 56000 CFM and 16" to 24" pressure. Steam pressures 360 to 575#, back pressure 10#.
Will sell turbines separately if desired.
Price reasonable.
Also—1—250 KW GE turbo generator unit, 3 phase, 60 cycle, 440 volts. Used one year.

G. M. De ROSE

2457 WOODWARD AVE.
706 DONOVAN BLDG.
DETROIT 1, MICH.

Circle 518 on Reader Service Card

FOR SALE

WHIRLEY GANTRY CRANE!

50-ton Washington Iron Works, Model 28H120K, 32' Track Gauge, 120' Boom Dismantled.

OTHER WHIRLEY CRANES AVAILABLE

Send for Specifications

SUNDFELT EQUIPMENT CO., INC.

802 E. Anaheim—Wilmington, Calif.
TErminal 5-5684

Circle 519 on Reader Service Card

TRANSFORMERS—60 CYCLE

Qu	KVA	Make	Type	Phase	Voltages
2	3000	Moloney	TCR	3	7200/6600-4160/3480
2	750	G.E.	K	1	4800-120/240
1	300	Pwms.	(Askarel)	3	1:470T/7200-240
2	250	G.E.	H Pyranol	1	4800/2820T/120/240
3	200	Al.-Ch.	CBS	1	2400/4160-240/480
3	200	Amer.	CC	1	4160/7200-240/480
3	75	G.E.	KF	1	2400/4160-120/240
3	50	G.E.	H	1	2400/4160-240/120
1	50	Amer.	Absetol	3	4160-120/208Y
2	3000	G.E.	OA-T	3	26,400-4160/2400
6	25	G.E.	Dry	1	2200-440

MOTOR GENERATOR SETS

Qu	KW	Make	Speed	DC	AC
1	75	EM	1200	250	Syn. 230V.
1	75	G.E.	1200	125	2300/4160 Syn.
1	175	West.	1200	125	4150 Syn.
1	300	G.E.	1200	250	2300/4160Y SR
1	300	Al.-Ch.	1200	125/250	Syn. 440V.
2	1000	West.	720	600	2300/4160Y Syn.
1	45	Cont.	1200	30	75 HP-440V Sq Cg

ENGINE GENERATOR SETS

1—Hercules Gas HXE 62.5 KVA Westghe 3/60/480 —1200

SLIP RING MOTORS

Qu	HP	Make	Speed	Type	Volts
2	40	West.	900	CW	220/440
1	40	G.E.	1800	MT	220
1	40	G.E.	900	MT548	440
1	75	G.E.	900	IM	440
1	100	West.	1800	T.E.F.C. B.B.	220
3	150	Allis-Ch.	1800	AY-RW	2200
1	250	West.	900	CW	440
1	350	West.	1800	CW	2200
1	450	West.	1800	CW-4-30-9	220
1	500	G.E.	450	MT	2300
1	500	G.E.	1200	M360Z	2300/4160Y
1	50	G.E.	870	MT552	220/440

D. C. MOTORS—230 VOLTS

Qu	HP	Make	Speed	Type
1	350	G.E.	1200	Pedestal
1	30	G.E.	1750	172 FR
1	30	West.	890/1400	SK-4G1848

SQUIRREL CAGE MOTORS, 3 PHASE, 60 CYC.

1—500 HP, 1200, Allis. Chalmers, 2300/4160Y
1—375 HP, 1150 RPM G.E. Type KT 550BB 2300V
2—300 HP, 1700 RPM, G.E. Elec. KF, TEFC, 2300V
5—150 HP, 1800 G.E. TEFC Exp. 220/440
1—100 HP, 1775 RPM G.E. KTP-543 B ph 60-440V.
1— 75 HP, 3600 RPM Cont. NP 506—440V Exp. P
1— 50 HP, 3600 Cont. Ex. Pr. 220/440
2—100 HP, 3600 RPM Cont. NP 585-8 440V X.P.
1—100 HP, 1200 RPM West-CHP 220/440
1—500 HP, 450 RPM GE TS 7656-2300

MOTORS—SYNCHRONOUS—3 ph. 60 cy.

100 HP 900 RPM G.E. Fum BL 2300V.
125 HP 600 RPM G.E. Type TS 2300 V.
125 HP 900 RPM Elect. Mach. 4800 V.
150 HP 3600 RPM G.E. type TS Fr. 954T 2300 V.
150 HP 1800 RPM G.E. Type TS 230 V
300 HP 720 RPM Elec. Machinery t.e.f.c. 2300 V.
325 HP 900 RPM West—2300 V.
400 HP 450 RPM Westinghouse Type HR 440 V.
75 HP 1200 RPM Crocker-Wheeler Type ALT 220/440V B.B.

FOR POWER
J.L. HEMPHILL & CO.

Circle 520 on Reader Service Card

FROM AIRCRAFT CARRIER "ENTERPRISE"

[4] 1000 KW GEARED TURBO-GENERATORS

For Condensing or Non-Condensing

1000 KW TURBO-GENERATOR COMPLETE WITH CONDENSERS CIRCULATING PUMPS CONDENSATE PUMPS AND SWITCH GEAR

GENERATOR: 1000 KW — type ATB-2 — G.E. — form H.L.—1250 KVA—3/60/450—1605 amps—3600 RPM—0.8 P.F.—field amps 87—typical serial No. 5358295—with 120 volt 11KW DC exciter—compound wound.

STEAM TURBINE: 1000 KW G.E.—type FSN-4R-FN30-05TG—rated 7964 RPM—exhaust 1 lb. absolute when condensing.

REDUCTION GEAR: S-11B—form A—RPM 7964/3600.

TURBINE STEAM PRESSURE: 375 lbs—175° F superheat-exhaust pressure 1 lb. absolute when condensing. Can be used condensing or non-condensing. Can be operated at reduced pressures.

BUILT AS MARINE UNITS USING FINEST MATERIALS. DRIP - PROOF CONSTRUCTION. UNITS ARE 18' LONG — 7'8½" WIDE. MOUNTED ON PRE-FAB SUB-BASE.

THE BOSTON METALS CO.

313 E. Baltimore St. Baltimore 2, Md.
ELGIN 5-5050 LEXINGTON 9-1900

Circle 521 on Reader Service Card

MISS POWER EQUIPMENT SAYS,

"For BIGGER SAVINGS and BETTER SERVICE, Get Our BARGAIN PRICES on Guaranteed NEW and REBUILT MOTORS"

SQUIRREL CAGE MOTORS NEW AND GUARANTEED REBUILT

HP	Make	Type	Speed
500	L.A. S.B. Splash. 440 Volt	FX-1465	3600
500	G.E. S.B. Open	IK	1200
400	West. S.B. Drip	CSP-581	1800
400	L.A. S.B. Splash		1800
400	G.E. S.B. Open	IK	1200
400	G.E. S.B. Open	IK-178	900
400	West. S.B. Open	CS	900
350	West S.B. Drip	CS-223536H	1200
300	G.E. S.B. Open	IK	1800
300	G.E. S.B. Open	IK	900
300	Cont. S.B. Splash	N-864	900
300	G.E. S.B. Open	IK	720
300	G.E. S.B. Open	KT-561	720
300	West. S.B. Open	CS-1002	600
300	G.E. S.B. Open	IK	600
250	G.E. S.B. Open	KT	1800
250	West. S.B. Splash	CS-875	1800
250	G.E. S.B. Open 2200 Volt	IK-16	1200
250	G.E. S.B. Open	IK	1200
250	G.E. S.B. Open	IK	900
250	G.E. S.B. Open	IK	720
200	G.E. S.B. Drip	K-8825	1800
200	West. S.B. Open	CS-858	1800
200	West. S.B. Open	CS	1200
200	G.E. S.B. Open	IK-15	1200
200	G.E. S.B. Open	IK-156	1200
200	G.E. S.B. Open 2200 v.	IK	1200
200	G.E. S.B. Open	IK	900
200	G.E. S.B. Open	K-8385	900
150	Wagner TEFCBB	588	1800
150	G.E. S.B. Drip	K-6324	1800
150	West. S.S.B. Open	CS-771-C	1800
150	Al. Chal. S.B. Open	AR	1800
150	West. S.B. Open 2200V	CS	1800
150	West. S.B. Drip	CS-772	1200
150	G.E. S.B. Open	KT	1200
150	G.E. S.B. Open	KT-557	1200
150	Ideal S.B. Drip New	A-586	1200
150	Al. Chal. TEFCBB	AZ	900
150	F.M. S.B. Open	H-24A	900
150	G.E. S.B. Open	IK	900
150	G.E. S.B. Open	IK	720
150	West. S.S.B. Open	CS-876-C	600
125	G.E. TEFCBB	K	3600
125	Burke S.B. Open 440 Volt	N-868	3600
125	Reliance T.E.F.C. S.B.	AA-5084	1800
125	G.E. S.B. Open	IK	1200
125	G.E. S.B. Splash	K-585	1800
125	West. S.S.B. Open	CS	1800
125	Al. Chal. S.B. Open	AR	1800
125	G.E. S.B. Open	KT-538	1200
125	G.E. S.B. Open	IK	1200
125	Ideal S.B. Open	A-585	1200
125	F.M. S.B. Open	H	900
125	G.E. S.B. Open	IK	720
125	G.E. S.B. Open	IK	600
100	Al Chal. T.E.F.C. S.B.	ARZ-823	3600
100	C.W. S.B. Open 2300 Volt	SC-445	3600
100	L.A. S.B. Drip New	OEX-445	3600
100	G.E. S.B. Open	KT-548	1800
100	G.E. S.B. Open	K-584	1800
100	Reliance S.B. Open	AA-5084	1200
100	West. TEFCBB	CS-770	1200
100	G.E. S.B. Open	KT-547	1200
100	Ideal S.B. Drip New	A-584	1200
100	Al. Chal. T.E.F.C. S.B. XP	28ES	900
100	F.M. S.B. Open	H20C	900
100	F.M. S.B. Open	H	720
100	F.M. S.B. Open	H	600
75	West. S.B. Open New	CS-444	3600
75	F.M. S.B. Open	H	900
75	F.M. S.B. Open	H	600
60	West. TEFCBB	CS-445	3600
60	G.E. TEFCBB	KF-445	3600
60	L.A. TEFCBB-XP	EX-445	3600
60	L.A. TEFCBB	JX-445	3600

CASH FOR YOUR SURPLUS

SEND YOUR LIST TODAY! NEW & USED Electrical Equipment

FREE CATALOG. This is a partial listing. We are continually changing our stock, and can fill your requirements at any time. Send for our free catalog. In Stock, fractional horsepower up to 500.

Motors, Control Equipment, AC and DC Generators, MG sets and transformers. PHONE or WIRE us COLLECT
LARGE LINE OF SLIP RING MOTORS & CONTROLS.

POWER EQUIPMENT CO.

8 CAIRN STREET • PHONE BEverly 5-1662 • P.O. BOX 514 • ROCHESTER 7, N.Y.

Circle 524 on Reader Service Card

AUGUST POWER BARGAINS

We own and Offer

1—400 KVA SUPERIOR DIESEL SET 300/2300 or 480 Volt 450 RPM. All accessories on foundation, Harrisburg, Pa. New 1950. For Quick Sale—Where Is—$8500.00.

2—515 CFM ING. RAND AIR COMPRESSORS Size 90 Model 40—125 PSI Base Mounted with 100 H.P. 3/60/220/440 Motors—Late—Guaranteed Phila. Stock. One Unit—$4750.00. 2nd Unit —$4250.00.

1—ING. RAND Type ESI Horiz. 14x13 Air Compressor 628 CFM Piston Disp. 100 Lb. U-Belt Drive. 100 H.P. Motor. Tank. Starter Aftercooler. New 1951—Reconditioned $6250.00.

1—PENNA Type 3AT Horiz. 9x9 Air Compressor 211 CFM Piston Disp. 100 Lb. U-Belt Drive 30 H.P. Motor. Starter New 1951 Reconditioned Phila. Stock $2500.00.

THE O'BRIEN MACHINERY CO.

1915 W. CLEARFIELD STREET PHILADELPHIA 32, PA.

Circle 522 on Reader Service Card

1—Gardner-Denver air compressor, 445 cfm @ 100# pressure, 6 cylinder, 2-stage, 1952. Req. 100 HP.

2—E. Keeler 200 HP water-tube boilers, 100 psi, Stoker fired, 1945.

1—Babcock & Wilcox #32E coal pulverizer, air swept, 75 HP.

1—24" x 538' long trough belt conveyor.

1—Riley Attrita coal pulv., 75 HP.

PERRY EQUIPMENT CORP.

1422 N. 6th St., Philadelphia 22, Pa.

Phone: POplar 3-3505

Circle 523 on Reader Service Card

POWER EQUIPMENT DIVISION

GENERATOR SETS

11—1250 KVA Natural Gas Engine Sets 3/60/2400/4160 with switch gear (can be seen running)
1—500 KW Condensing 200 PSI Turbine

TRANSFORMERS

1—6000 KVA 3/60/44000—4160 Substa.
3—500 KVA 1/60/66000— 480
6—450 KVA 3/60/13800— 460
3—333 KVA 1/60/2300/4160 Y—480

CRANES

40/10 ton OET 47'3" Span 75' Lift AC
25 ton Powerhouse 36'6" Span AC
6 ton OET 43' Span 20' Lift DC

BOILERS

40,000#/hr. 225 PSI B&W Type F22
25,000#/hr. 450 PSI @ 738°F. Stirling
18,000#/hr. 160 PSI Keeler

NEW UNASSEMBLED B&W, F.W., C.E. complete with Superheater, Economizer, Soot Blowers, Oil Burners, Steel Encased
44500#/hr. 450 PSI 735°F.
35000#/hr. 285 PSI 577°F.

HEAT & POWER CO. INC.

60 East 42nd St., New York 17, N.Y.
310 Thompson Bldg., Tulsa 3, Okla.

Circle 525 on Reader Service Card

37 Years Dependable Service

SLIP RING MOTORS 3 Ph., 60 Cy.

H.P.	Volts	Make	Speed
500	4000/2300	G.E.	600
450	4000/2300	G.E.	1200
400	2300/440	G.E.	600
400	4000/2300	Whse.	720
300	4000/2300	G.E.	720
300	2300	G.E.	900
300	440	G.E. (hoist)	600
300	440	Whse.	3600
225	4000/2300	G.E. (hoist)	600
200	2300	G.E.	900
200	2300/440	G.E.	720
125	2300	G.E.	600

AC GENERATORS or SYN MOTORS, 60 Cy.

H.P.	Volts	Make	Type	R.P.M.
400	2300	G.E.	TS	1800
400	2300/440	G.E.	ATI	720
300	2300/440	G.E.	TS	1200
200	440	G.E.	TS	600
150	440/220	Whse.	G	1200
125	440/220	Whse.	HR	400

SQUIRREL CAGE MOTORS

500	2300/4000	Elliott	SC	1800
400	2300	G.E.	FT	3600
400	2300/4000	G.E.	K	1200
350	2300/4000	G.E.	SEDP	3600
350	2300/4000	G.E.	K	600
300 (2)	2300	G.E.	FT	3600
300	2300/4000	L. Allis.	FS	1800
300	2300/4000	Cont'l.	Spl.-Prf.	720
300	2300/400	G.E.	KT	600
250	2300/4000	G.E.	K	720
200	2300	G.E.	KT	1800
200	2300	Cont.	TEFC	3600
150	440	Whse.	X-pf.	3600
150	440/220	Cont'l.	X-pf.	1800
150	440/220	G.E.	TEFC	720
150	2300/440	G.E.	TEFC	3600
125	2300/440	G.E.	FT	1200
100	440	Whse.	X-pf.	3600
100 (2)	440	Cont.	X-pf.	1800
100 (2)	4000/2300	L. Allis	OX	1200
100	2300	Cont'l.	OX	1200
60 (2)	440	Cont'l.	X-pf.	1800

CIRCUIT BREAKERS, 2 Pole

4—1200 Amp., DA-50, Whse., 600 V., Air
1—600 Amp., G.E., 15 KV, Sol. oper.
3—600 Amp., G.E., 15 KV, manual
1—600 Amp., Whse., 7.5 KV, outdoor, New.

D. C. MOTORS

H.P.	Volts	Make	Type	Speed
150	230	El. Dyn.	B/brg.	800
90	230	G.E.	CD	1750
54	230	G.E.(4)	CD	1150

MOTOR GENERATOR SETS

KW	Make	Input.. AC	Motor Type	Output V., DC
300	Whse.	4150/400	Syn.	250/125
150	G.E.	440/220	Syn.	250
125	G.E.	440/220	Sq. Cs.	125
100	G.E.	2300/440	Syn.	250
75	Cr. Wh.	440/220	Sq. Cs.	240/120
65	G. E. B	2300/440	Sq. Cs.	230

TRANSFORMERS 60 Cy.

1—500 kva, Al Ch. 2400/4160Y—400 volts, 3 ph.
2—500 kva, G.E., 13800—240/480 V.
1—240 kva, Mol., 13,800—2300 V.
2—333 kva, G.E., 13,800—2400 V.
2—333 kva, G.E., 2400—240/120 V.
3—333 kva, Mol., 2400—240/480V.
3—200 kva, G.E., 2400—480V. Pyr.
3—200 kva, G.E., 13,800—480 V
2—200 kva, G.E. 4150—480/240 V.
3—167 kva, Whse., 4150—480 V.
3—150 kva, Al. Ch., 2400—220 V.
3—150 kva, G.E., 13,800—2300 V.
3—100 kva, Whse., 2400—240/480 V., Dry
3—100 kva, G.E. 2400—120/240 V., Pyr.

GASOLINE—ENGINE GENERATOR SETS

2—37½ kva, 1800 R, 220 V 3/60, Cont'L, 6 cyl.

only partial listing

STEPHEN HALL & CO.
HARRY J. RICE, Pres.
625 ADAMS ST., HOBOKEN 2, N. J.

Circle 526 on Reader Service Card

MODERN POWER BOILERS

2—Babcock & Wilcox	—265,000#/h—	730 psi
1—Combustion-Engineering	—110,000#/h—	675 psi
1—Riley	—100,000#/h—	450 psi
1—Babcock & Wilcox	—100,000#/h—	450 psi
1—Babcock & Wilcox	— 90,000#/h—	265 psi
1—Combustion-Engineering	— 75,000#/h—	250 psi
1—Babcock & Wilcox	— 70,000#/h—	450 psi
1—Riley	— 60,000#/h—	265 psi
1—Combustion-Engineering	— 54,000#/h—	250 psi
2—Combustion-Engineering	— 50,000#/h—	250 psi
1—Babcock & Wilcox	—45,000#/h—	450 psi
1—Foster-Wheeler	— 40,000#/h—	200 psi
2—Babcock & Wilcox	—40,000#/h—	250 psi
1—Babcock & Wilcox	— 27,500#/h—	450 psi
1—Edgemoor	— 25,000#/h—	450 psi
2—Riley	— 21,000#/h—	250 psi
2—Riley	— 18,000#/h—	200 psi

MIDWEST BOILER & TURBINE CO.
WARNER, NEW HAMPSHIRE

Circle 532 on Reader Service Card

BOILERS

FOR SALE, SPECIALLY
BABCOCK & WILCOX
SECTIONAL HEADER
ARG CHEMICAL MACHINERY
507 Fifth Avenue, New York 17, N. Y.

Circle 533 on Reader Service Card

AXIAL FLOW FANS

From unfinished Battle Cruiser "Hawaii"

All New! Installed but never run!

RELIANCE MOTORS—ALL 440/3/60

22500 CFM @ 3.4" static pressure; 25 HP @ 1760 RPM—39" ID top; 54" OD bottom; 40" long.
18810 CFM @ 3" static pressure; 15 HP @ 1760 RPM—30" ID both ends; 30" long.
17750 CFM @ 3" static pressure; 15 HP @ 1760 RPM—33½" ID both ends; 30" long
17475 CFM @ 3¼" static pressure; 15 HP @ 1760 RPM—36" ID both ends; 30" long.
17040 CFM @ 4" static pressure; 17½ HP @ 1735 RPM—30" ID top; 51" OD bottom; 37" long.
16865 CFM @ 4.2" static pressure; 15 HP @ 1760 RPM—36" ID top; 51" OD bottom; 37" long.
16000 CFM @ 3.7" static pressure; 15 HP @ 1730 RPM—30" ID top & bottom; 37" long.
15840 CFM @ 3.4" static pressure; 15 HP @ 1760 RPM—36" ID top; 51" OD bottom; 37" long.
15820 CFM @ 4" static pressure; 15 HP @ 1760 RPM—36" ID top; 51" OD bottom; 37" long.
13815 CFM @ 3¼" static pressure; 12½ HP @ 1760 RPM—34" ID both ends; 37" long.
11530 CFM @ 3.2" static pressure; 10 HP @ 1740 RPM—31½" ID both ends; 37" length.
10300 CFM @ 2.85" static pressure; 7½" HP @ 1745 RPM—29" ID top; 37" OD bottom; 39½" long.
6820 CFM @ 3.2" static pressure; 7½ HP @ 1750 RPM—27" ID top; 36" OD bottom; 39½" long.
5090 CFM @ 3" static pressure; 5 HP @ 1780 RPM—25" ID both ends; 31" length.
5160 CFM @ 2.1" static pressure; 3 HP @ 3450 RPM—25" ID both ends; 30" long.
4880 CFM @ 2" static pressure; 3 HP @ 3450 RPM—25" ID both ends; 30" long.
3700 CFM @ 2.5" static pressure; 3 HP @ 3450 RPM—25" ID both ends; 30" long.
3000 CFM @ 3.4" static pressure; 3 HP @ 3450 RPM—25" ID both ends; 30" long.
2200 CFM @ 3" static pressure; 1½" HP @ 3550 RPM—18½" ID both ends; 25" long.

THE BOSTON METALS CO.
313 E. Baltimore St., Baltimore 2, Md.
ELGIN 5-5050 — LEXINGTON 9-1900

Circle 527 on Reader Service Card

POWER UNITS
FOR SALE

2—1000 KW Waterwheel Plants, Modern 230 foot head, Horizontal, 720 RPM, 3 phase, 60 cycle, 2400 Volts AC.

3—General Electric Transformers 833 KVA, 34500/2400/4160 Volts, Modern.

1—400 KW Condensing Turbo Generator, 400 PSI, 3 phase, 60 cycle, 440 Volts, AC.

1—5000 KW Condensing Turbo Generator, 400 PSI, 3 Phase, 60 Cycle, 2300 Volts AC, 740° F.T.T.

SUNDFELT EQUIPMENT CO., INC.
802 E. Anaheim St.
Wilmington, California
TErminal 5-5684

Circle 528 on Reader Service Card

FOR SALE:
KEYSTONE STEAM GENERATOR

manufactured by Erie City Iron Works 1953. Size 606 Hp. 2 drum, bent tube 2" O.D. Heating surface 3,000 sq. ft., furnace vol. 280 cu. ft., nominal rating 20, 700# hr., operating pressure 125#, #6 fuel oil.

Also, 19,000 gal. fuel oil storage tank.

FS-4731, POWER
Class. Adv. Div., P.O. Box 12, N.Y. 36, N.Y.

Circle 529 on Reader Service Card

USED BOILERS

1—100 H.P. 150 P.S.I. Ameseum 6 oil complete
1—150 H.P. 150 P.S.I. Loffel Scotch Marine w/175 York #4 oil, stack and condensate return system
1—300 H.P. V.L. Erie City W.T., 20,000 lb. max w/ underfeed stoker and return pump

E. A. DRAKE INC.
Box 103 North Salina Station, Syracuse, New York

Circle 530 on Reader Service Card

FOR SALE: BOILER

1—Farrar & Trefts #81150 Scotch Power Boiler, 1523 sq. ft. heating surface, 150 lb. steam design pressure complete with Dayton Automatic Stoker #10, controls, pumps, deaerating heater and water softener. Complete details on request, National Gypsum Company, Purchasing Department, Buffalo 2, New York.

Circle 531 on Reader Service Card

SEARCHLIGHT EQUIPMENT LOCATING SERVICE

No Cost or Obligation

This service is aimed at helping you, the reader of "SEARCHLIGHT", to locate Surplus new and used power equipment not currently advertised. This service is for USER-BUYERS only. How to use: Check the dealer ads to see if what you want is currently advertised. If not, send us the specifications of the equipment and/or components wanted on the coupon below, or on your own company letterhead to:

SEARCHLIGHT EQUIPMENT LOCATING SERVICE
c/o POWER
Classified Advertising
P.O. Box 12, N. Y. 36, N. Y.

Your requirements will be brought promptly to the attention of the equipment dealers advertising in this section. You will receive replies directly from them.

SEARCHLIGHT EQUIPMENT LOCATING SERVICE,
c/o Power,
P.O. Box 12, N.Y. 36, N.Y.

Please help us to locate the following used equipment:

.....

.....

NAME .....

TITLE ..... COMPANY .....

STREET .....

CITY ..... ZONE ..... STATE .....

8/60

SLIP RING MOTORS—3 Ph., 60 Cy.

Qu.	HP	Make	Type	Volts	Speed
1 new	5500	G.E.	MT-30	4160/6600	240
1	2500	Al. Ch.		2200	300
1	1800	West.	HP1227	2200	252
1	1000	G.E.	M-575a	2200	1200
1	500	Al. Ch.		2200	293
1	500	West.	CW	2200	594
1	300	West.	CW-955C	2200	1150
1	400	West.	CS-4-22-11	220	1778

SYNCHRONOUS MOTORS—3 Ph., 60 Cy.

2	5000	Al. Ch.		13800/6900	514
1 new	4000	West.		4160/2300	1200
3	1750	G.E.	T8	4160/2300	720
1	1500	West.		2300	514
5	1250	El. Prd.		2300	1200
1 new	920	G.E.		2400/440/220	300
3	700	West.		2300	1200
1	500	West.		2300	1800
1	450	West.		2300	1257½
6	1500	G.E.	T8	4160	225

SQUIRREL CAGE MOTORS 3 Ph., 60 Cy.

1	1250	Al. Ch.		2300	3570
3	2000	Ideal	M-5	4160	900
1	800	West.	C8	2300	580
1	800	West.	C8-44	4000/2300/440	1787
1	600	West.	C8	440	3570
1	600	G.E.	K-63398	440	3570
2	450	G.E.	K-63468	2300	3570

TRANSFORMERS — 60 Cycle

Qu.	KVA	Make	Type	Ph.	Voltage
1	3000	G.E.		3	22,500x480
1	1750	Penna.	OISC	3	2200x220
1	1500	West.	Dry	3	4160x2560
6	1500	West.	SL	1	24,000x480
1	800	Wagner		3	2300x220/440
3	833	Penna.	OISC	1	22000x2300
2	750	G.E.	Pyranol	3	4160x480/277

M-G SETS — 3 Ph. 60 Cy.

Qu.	KW	Make	RPM	D.C. Volts	A.C. Volts
2	3500	Al. Ch.	514	250/700	13800/6900/4160
3	1200	G.E.	720	250	2300/4160
1	1000	West.	720	250	2400
1	400	West.	1200	250	2300

D.C. MOTORS — MILL TYPE

Hp	Make	Speed	Type	Volts
850	Westinghouse	250/500	QM-887.1	250
2000	G.E.	90/180		600

DUQUESNE ELECTRIC & MFG. CO.
6415 Hamilton Ave., Pittsburgh 6, Penna.
Write for our new catalog.

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DEAERATING FEED TANKS

2—Cochrane vertical cylindrical deaerating feed tanks of STAINLESS STEEL CONSTRUCTION. Upper section: 8'-3" I.D. by 3'-7" high outside, contains direct contact feed water heater, an internal deaerating atomizing valve assembly, an external valve control unit, and a tubular surface type vent condenser. Lower section: 10'-6" I.D. by 8'-2" high outside and used for storage of deaerated boiler feed water. Delivered capacity 414,500 pounds per hour feed water maximum rating. For price or additional information, contact:

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ZIDELL EXPLORATIONS, INC.

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CApitol 8-8691

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4—1000KW Mod. 6RC-45-CD6 Auto. Subs.
2— 500KW Mod. 6RC-45-CH2 Auto. Subs.

1948 Vintage still like NEW condition. Can be inspected under power at Birmingham. Priced at $35. per KW (Less than ½ replacement).

S. M. DAVIS Box 1487, E. St. Louis, Illinois

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Gas or DIESEL GENERATOR UNITS
Complete Switchboard Design and Construction
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Phone: DElaware 2-8300

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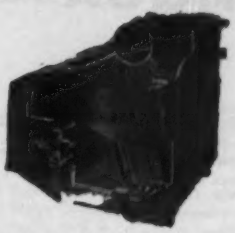
BOILERS NEW UNASSEMBLED



# Steam/hr.	Key	PSI	Temp.
122,500	DF	565	850
121,650	DF	565	850
60,000	SF	435	750
74,000	H	280	500
55,000	A	240	—

DF Double Furnace, SF Single Furnace (illustrated), bent water tube boilers w/economizers and superheaters, B & W's and Foster Wheelers.

H Header type, straight tube, B & W.

A 3 drum, single furnace, Wickes.

Pelnik-Loconti Industrial Supply, Inc.

315 Oriskany St., Yorkville, N.Y.

Utica, N. Y. Ph. RE 6-4621, RE 2-4513

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NEW EQUIPMENT

from the unfinished Battle Cruiser "Hawaii"

Material installed but unused, and all in prime condition

8 B&W BOILERS

150,000 lbs/hr—634 lbs. WP—650° TT—6053 sq. ft. generating surface. (Can be converted to natural gas or #2 oil) 11' wide—21' high—15' deep.

4 LARGE DEAERATING FEED HEATERS

833,820 lbs/hr—manufactured by Worthington—test pressure 45 pounds.

8 MAIN CONDENSATE PUMPS

4 motor driven—4 turbine driven—480 GPM @ 36 lbs—11.5" submergence—1170 RPM—BHP 27.3 (Motor driven: G.E. 30 HP motor 440/3/60—1170 RPM. Turbine driven: Sturdevant turbine—500 lbs—20 lbs. B.P.—27.3 BHP @ 5480 RPM—gear 1170 RPM—1239 lbs. steam/hr.)

THE BOSTON METALS CO.
313 E. Baltimore St., Baltimore 2, Md.
ELGIN 5-5050 — LEXINGTON 9-1900

Circle 540 on Reader Service Card

FOR SALE

1500 KW, 80% Power Factor, 3 phase, 60 cycle, 2300 volts, 3600 RPM, General Electric 5-stage noncondensing steam turbine generator unit, 375 PSIG, 700° FTT, 125# exhaust back pressure, complete with direct connected shaft exciter and switchgear. Excellent condition—available immediate delivery.

EUCLID ENGINEERING CORPORATION
909 National City East Sixth Building
Cleveland 14, Ohio

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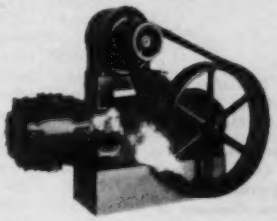
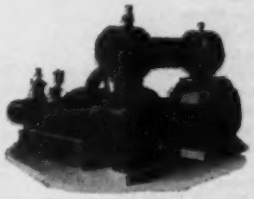
Good Fiscally and Mechanically



NEVER USED

9x9 Chic. Pn. T.B. with unused accessories complete—40 H.P. motor, starter, 24"x6' ASME Air Receiver, Aftercooler, Separator over-head M-V-Drive, and filter. SPECIAL $3975.00



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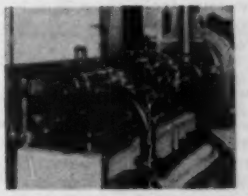
2950 CFM 100-125 psi 150 psi steam 19x30x30x19x24 Ing. Rand XPV overhauled and updated 1954. Inspection invited.



1670 CFM Actual Free Air Delivery 100# 600 RPM 300 HP Motor.—Fuller Model C900-300H Rotary Multi-Vane, Roller bearing, horizontal, two stage, water-cooled air compressor equipped with: Mechanical force feed lubricator; Oil bath air inlet filter; Separately mounted intercooler; Unloader; Discharge Muffler. FLEXIBLE COUPLED TO: 300 HP Westinghouse 600 RPM, 80% power factor synchronous motor 3/60/440 volt with Westinghouse NA-7A711 across-the-line starter and with 5 KW, 125 volt M.G. set with starter. Now in the Fifties.

— CAN BE SEEN RUNNING —
INSPECTION INVITED

1721 CFM Displacement 90-110# 225 RPM. 23/14 x 16 Ingersoll Rand PRE-2 two stage, double acting, duplex, water cooled, heavy duty, horizontal, synchronous motor driven air compressor with: Step control; Intercooler with safety valve; Mechanical force feed lubricator. DIRECT CONNECTED TO: 285 HP General Electric TS 225 RPM, 80% power factor 3/60/2300 volt engine type synchronous motor complete with exciter and starter.

**For any size or make compressor try American Air.*

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Dell Ave. & Power St. North Bergen, N. J.
UNion 5-4848

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Advertisers' Index

A

Aerotec Industries ..... •
Air Preheater Corp. ..... •
Allgemeine Elektricitats-Gesellschaft ..... Second Cover
Allis-Chalmers Mfg. Co. 147, 149
Allpax Company, Inc. 108
Alpha-Molykote Corp. ..... •
Aluminum Company of America ..... •
American Brass Co. ..... •
American Engineering Co. ..... •
American Meter Co. Pump Div. 186
American Pulverizer Co. 126
American Standard Industrial Div. 22
Ames Iron Works ..... •
Anchor Packing Co. 51
Anderson Co., V. D. ..... •
Armstrong Machine Works 177
Asea Electric, Inc. ..... •
Associated Laboratories, Inc. ..... •
Atlas Valve Co. ..... •
Atomics International A Div. of North American Aviation, Inc. 113
Aurora Pump Div. New York Air Brake Co. 152
Avondale Marine Ways, Inc. ..... •

B

B-I-F Industries, Inc. ..... •
Babbitt Steam Specialty Co. 140
Babcock & Wilcox Co. Boiler Div. 4-5, 48
Babcock & Wilcox Co. Tubular Products Div. ..... •
Babcock & Wilcox Co. Tubular Products Div., Fittings Dept. •
Badger Mfg. Co. ..... •
Bailey Meter Co. 10-11
Baldwin-Ehret-Hill, Inc. ..... •
Baltimore & Ohio Railroad ..... •
Barco Manufacturing Co. 196
Bell & Gossett Co. 141
Belmont Packing & Rubber Co. ..... •
Bituminous Coal Institute ..... •
Black, Sivalls & Bryson, Inc. ..... •
Blackmer Pump Co. ..... •
Blaw-Knox Equipment Div. Blaw-Knox Co. 114
Boiler Tube Co. of America ..... •
Bonney Forge & Tool Works ..... •
Borg-Warner Mechanical Seals 184
Bridgeport Brass Co. ..... •
Brown Company 122
Brown Boveri Corp. 165
Buell Engineering Co. 32
Buffalo Forge Co. 28-29
Bussmann Mfg. Div. McGraw-Edison Co. 68-69
Byron Jackson Pumps, Inc. 131

C

Capitol Pipe & Steel Products, Inc. ..... •
Carling Turbine Blower Co. 128
Carpenter Steel Co. Alloy Tube Div. ..... •
Catawissa Valve & Fittings Co. ..... •
Chesapeake & Ohio Railway 156-157
Chesterton Co., A. W. ..... •
Chicago Pneumatic Tool Co. ..... •
Clarage Fan Co. 145
Clark Bros. One of the Dresser Industries 56-57
Clayton Manufacturing Co. 161
Cleaver-Brooks Co., Boiler Div. 144
Cochrane Corporation 63
Colonial Plastics Mfg. Co. 146
Combustion Engineering, Inc. 40-41
Condec Group Power Equipment Div. 172, 173
Condenser Service & Engrg. Co. 188
Cooper-Bessemer Corp. ..... •
Copes-Vulcan Div. Blaw-Knox Company 12-13
Coppus Engineering Corp. 171
Corning Glass Works 20
Crane Company 18-19
Crane Packing Co. ..... •
Crawford Fitting Co. ..... •
Curtiss Wright Corp. Marquette Div. 229
Cyclotherm Div. of Crane Co. 27

D

Dearborn Chemical Co. ..... •
deLaval Ljungstrom Turbine Co. ..... •
Detroit Stoker Company 1
Diamond Power Specialty Corp. 6-7, 49
Dodge Manufacturing Corp. 54-55
Dow Chemical Co. 155
Dow Corning Corp. 131
Dow Industrial Service Div. of Dow Chemical Co. ..... •
Dravo Corp. Grating Div. 130
duPont de Nemours & Co., Inc., E. I. Industrial & Biochemicals Dept. ..... •

E

Eagle-Picher Co. 26
Eastern Gas & Fuel Assoc. 21
Edward Valves, Inc. 58-59
Electric Machinery Mfg. Co. ..... •
Elgin Softener Corp. ..... •
Elliott Company 194
Elliott Company—Lagonda Plant 110
Elliott Company—Roto Plant ..... •
Emhart Mfg. Company Maxim Div. ..... •
Engineer Company ..... •
Erie City Iron Works 60-61

F

Faber Engineering Co., Inc. 169
Fairbanks Company ..... •
Fairbanks, Morse & Co. 178-179
Fairmount Chemical Co. 128
Farris Engineering Corp. Mil Division 30-31
Fisher Governor Co. 127
Flexitallic Gasket Co. 189
Flexonics Corp. ..... •
Fluor Products Co. ..... •
Fly Ash Arrestor Corp. ..... •
Foster Co., Benjamin ..... •
Foster Wheeler Corp. 46-47
Foxboro Company 151
Frick Company ..... •
Fuller Company ..... •

G

Garlock Incorporated 99
General Controls 191
General Electric Co. 33-34-35-36-37-38, 227
Goodyear Tire & Rubber Co. Industrial Products Div. ..... •
Goulds Pumps, Inc. 240
Grinnell Company 195
Griscom-Russell Co. ..... •
Gustin-Bacon Mfg. Co. ..... •

H

Haering & Co., Inc., D. W. ..... •
Hagan Chemical & Controls, Inc. 200
Hall Laboratories ..... •
Hawker Siddeley Group ..... •
Hitachi, Ltd. 137
Hungerford & Terry, Inc. 188
Hupp Aviation Division Hupp Corporation 97

I

I-T-E Circuit Breaker Co. 52-53
Illinois Stoker Co. ..... •
Illinois Water Treatment Co. ..... •
Industrial Combustion, Inc. 112
Inflco Inc. ..... •
Ingersoll-Rand Co. ..... •
International Boiler Works ..... •
International Nickel Co., Inc. Huntington Alloy Products Div. 164
Iron Fireman Mfg. Co. ..... •

J

Jenkins Bros. 163
Jerguson Gage & Valve Co. 173
Johns-Manville ..... •
Johnson Service Co. ..... •

K

Kato Engineering Co. ..... •
Keasbey & Mattison Co. 62
Keeler Co., E. ..... •
Kiley & Mueller, Inc. ..... •
Kilby Steel Co. 129
Kirk & Blum Mfg. Co. ..... •
Klipfel Valves, Inc. ..... •
Koppers Co., Inc. Electrostatic Precipitators 199

L

Lenger, Inc. ..... •
Leslie Company 42-43
Limitorque Corp. ..... •
Link-Belt Company 185
Liquidometer Corp. ..... •
Lunkenheimer Company ..... •

M

Madden Corp. ..... •
Magnatrol Valve Corp. 140
Manning, Maxwell & Moore, Inc. ..... •
Mansfield & Green, Inc. 174
Marley Company 175
Marsh Instrument Company Div. of Colorado Oil & Gas Corp. ..... •
Mason-Neilan Div. of Worthington Corp. ..... •
McDonnell & Miller, Inc. 142
McGraw-Hill Book Co. 187
McNally Pittsburg Mfg. Corp. 148
Mears Kane Ofeldt, Inc. ..... •
Mercoid Corp. ..... •
Midwest Piping Co., Inc. 66
Minneapolis-Honeywell 153-154
Mobil Oil Company ..... •
Moeller Instrument Co., Inc. 192
Morton Salt Co. Industrial Div. ..... •
Murray Iron Works Co. 109
Murray Mfg. Co., D. J. 150

N

Nalco Chemical Co. 167
National Supply Co. ..... •
National Tube Div. of U.S. Steel 176

This index is a service to readers. Every effort is made to maintain its accuracy, but POWER cannot assume responsibility for errors or omissions. When a star appears after the name, the advertisement does not appear in this issue but appeared in an issue within the previous three months.

Niagara Blower Co. ... *
Nordberg Mfg. Co. ... *
Norfolk & Western Railway ... 104-105
North American Mogul Products Co. ... *

O

OPW-Jordan Corp. ... *
Ohio Brass Company ... Third Cover
Ohio Injector Co. ... 139
Onan & Sons, Inc., D. W. ... 16-17
Orr & Sembower, Inc. ... 190

P

Patterson-Kelley Co. ... *
Peabody Engineering Corp. ... *
Peerless Pump, Hydronamics Div. Food Machy. & Chemical Corp. ... 70
Pennsylvania Crusher Div. Bath Iron Works Corp. ... *
Pennsylvania Pump & Compressor Co. ... 124
Pfaudler Permutit, Inc. ... 138
Pfizer & Co., Inc., Charles Chemical Sales Div. ... *
Philadelphia Gear Corp. ... *
Philips Export Co. ... 183
PIC Design Corp. ... *
Pioneer Service & Engrg. Co. ... *
Pittsburgh Piping & Equipment Co. ... *
Porter Co., Inc., H. K. Forge & Fittings Div. ... *
Powell Co., Wm. ... 111
Powers Regulator Co. ... *

R

R-P & C Valve Div. Amer. Chain & Cable Co., Inc. ... 197
Raybestos-Manhattan, Inc. Manhattan Rubber Div. ... *
Raybestos-Manhattan, Inc. Packing Div. ... *
Reliance Gauge Column Co. ... *
Rempe Company ... 174
Republic Flow Meters Co. ... 132-133
Republic Steel Corp. Steel & Tubes Div. ... 14-15
Research-Cottrell, Inc. ... 193
Revere Copper & Brass Inc. ... *
Ridge Tool Company ... 116
Riggio Co., Inc., Frank D. ... 174
Riley Stoker Corporation ... 94-95
Robvon Backing Ring Co. ... 23
Rohm & Haas Co. ... 39

S

Sarco Company, Inc. ... 168, 169
Schaub Engineering Co., Fred H. ... 162
Scovill Mfg. Co. ... *
Smith Corp., A. O. ... *
Southwestern Engrg. Co. ... *
Spence Engineering Co. ... *
Squires Co., C. E. ... 50
Standard Oil Co. of Indiana ... 125
Stephens-Adamson Mfg. Co. ... 117
Stickle Steam Specialties Co. ... *
Stock Equipment Co. ... *
Stockham Valves & Fittings ... *
Strong, Carlisle & Hammond ... *
Superior Combustion Industries, Inc. ... 101

T

Terry Steam Turbine Co. ... 115
Thompson-Ramo-Wooldridge Prod. Co., Inc. Tapco Group ... 143
Trinity Equipment Corp. ... *
Tube Turns Div. of Chemetron Corp. ... 8-9

U

Union Asbestos & Rubber Co. Fibrous Products Div. ... *
Union Iron Works ... *
United Electric Coal Companies ... *
United States Motors Corp. ... 170
United States Rubber Co. Mechanical Goods Div. ... 44-45
United States Rubber Co. Textile Div. ... 170
Universal Atlas Cement Div. of U.S. Steel ... *

V

Velan Engineering Co. ... *
Vibration Mountings, Inc. ... 150
Vico Company ... 140
Viking Pump Co. ... *
Virginia Gear & Machine Co. ... *
Vogt Machine Co., Henry ... 163

W

Wallace & Tiernan Inc. ... 182
Walworth Company ... *
Warren Pumps, Inc. ... *
Webster Manufacturing, Inc. ... *
Western Chemical Co. ... *
Western Precipitation Corp. ... *
Westinghouse Electric Corp. ... 64-65
Westinghouse Electric Corp. Sturtevant Div. ... *
Wheeler Mfg. Co., C. H. ... *
Where to Buy ... 230
Wickes Boiler Co. ... 123
Wiedeke Co., Gustav ... *
Williams Gauge Co., Inc. ... *
Wolverine Tube Div. of Calumet & Hecla, Inc. ... *
Worthington Corp. ... Back Cover

Y

Yarnall-Waring Company ... 24-25, 118
Yuba Heat Transfer Div. Yuba Consolidated Industries ... *

Z

Zallea Brothers ... *

Professional Services ... **230**

CLASSIFIED ADVERTISING

F. J. Eberle, Business Mgr.

EMPLOYMENT OPPORTUNITIES ... 231

EQUIPMENT
(Used or Surplus New) For Sale ... 231-235

WANTED
Equipment ... 231

ADVERTISERS INDEX

Ajax Electric Motor Corp. ... 231
Allied Electric Co. ... 231
American Air Compressor Corp. ... 237
Arg Chemical Machinery ... 236

Bechtel Corp. ... 231
Belyea Company, Inc. ... 232
Boston Metals Co. ... 232, 233, 234, 235, 236, 237
Brew, Weltman & Co. Inc. ... 232

Chicago Electric Company ... 233

Davis, Samuel M. ... 237
DeRose, G. M. ... 234
Drake, Inc., E. A. ... 236
Duquesne Electric & Mfg. Co. ... 237

Electric Equipment Co. ... 237
Electric Service Co. ... 232
Erie Electric Company, Inc. ... 234
Euclid Engineering Corp. ... 237

Hall & Company, Stephen ... 236
Heat & Power Company, Inc. ... 235
Hemphill & Company, J. L. ... 235

International Power Machy. Co. ... 236

Knox Company, Earl E. ... 234
Kuljian Corporation ... 231

MacCabe Company, T. B. ... 234
Midwest Boiler & Turbine Company ... 236

National Gypsum Co. ... 236

O'Brien Machinery Company ... 235

Pelnik-Loconti Industrial Supply Co. ... 237
Perry Equipment Corporation ... 235
Power Equipment Company ... 235

Schoonmaker Co., A. G. ... 233
Sundfelt Equipment Co., Inc. ... 234-236

Universal Power Engineering Co. ... 237
Utilities Machinery Corporation ... 232

Wabash Power Equipment Company ... 234
Wagner Company, Arthur G. ... 232
Weaver Inc., Charles ... 233
Whisler Equipment Company ... 234
Worthington Corp. ... 231

Zidell Explorations, Inc. ... 237

GOULDS PUMPS, INC.

DEPT. PO-80, SENECA FALLS, NEW YORK

Specialists in Pumps!

The largest plant of its kind in the world *plus* over 100 years' experience in pump manufacturing—that's what equips Goulds to answer all your liquid-handling needs. We'll build you a pump specially for your job or draw from our wide line of standard pumps to supply you. Complete details on any pump are available in the Bulletins indicated. Write for your copy.

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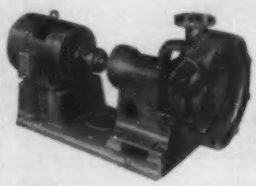
GOULDS-PFAUDLER GLASSED PUMP



Revolutionary new pump designed for handling corrosive liquids. All parts in contact with liquid are glass—fused to metal. Handles all acids except hydrofluoric, and all alkalies to pH 12. Four sizes, with capacities to 700 GPM, heads to 140 ft.

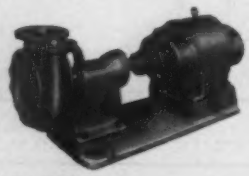
FIG. 3708 — BULLETIN 725.2.

SINGLE-STAGE CENTRIFUGALS

Highly efficient open impeller pumps available in 13 sizes for both motor and belt drives. Capacities up to 3000 GPM, with heads up to 180 ft. at 1750 RPM. Well suited for irrigation, general industrial processes, and slurries.

FIG. 3189 — BULLETIN 720.4.

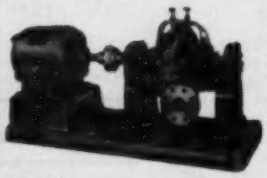
SPECIAL METAL CHEMICAL PUMPS



Available in stainless steel, aluminum-bronze, etc. Motor- and belt-driven, for handling corrosive liquids, food products, chemicals. Handle liquids to 350° F., with cooling of head and quenching of gland. Ten sizes, with capacities to 720 GPM, heads to 200 ft.

FIG. 3715 — BULLETIN 725.4.

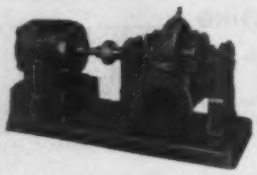
TWO-STAGE CENTRIFUGALS



Eight sizes provide heads up to 1000 ft., capacities to 1200 GPM, depending on heads. Horizontally split casing. Opposed impellers, with labyrinth diaphragm for maintaining thrust balance.

FIG. 3305 — BULLETIN 722.6.

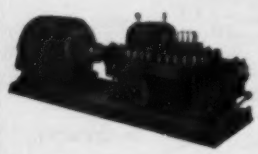
DOUBLE-SUCTION CENTRIFUGALS



Capacities from 200 to 6400 GPM. Heads up to 425 ft. Three shaft and rotating parts assemblies provide for 66 sizes and 132 pump combinations. Horizontally split casing.

FIG. 3405 — BULLETIN 721.6.

MULTI-STAGE CENTRIFUGALS



Medium- and high-pressure multi-stage pumps. Fig. 3330 is furnished in sizes from 3 to 8 inches, up to 6 stages, with capacities ranging from 40 to 2000 GPM, heads to 850 ft. Fig. 3360 furnished in 3, 4, 6, and 8 inch sizes, up to 8 stages, with capacities ranging from 50 to 2250 GPM, heads to 3050 ft.

FIGS. 3330-3360 — BULLETINS 722.1 and 722.4.

"SUPPORT HEAD" CENTRIFUGALS

Built in 24 sizes, with capacities up to 4000 GPM and heads up to 400 ft. Designed for standard electric motor drive; readily adaptable for belt drive. A substantially built line for general and special applications with many new improvements.

FIG. 3755 — BULLETIN 715.1.

MODULAR VERTICAL PUMPS

SUMP

For pit depths to 20 ft. in 6 inch increments. Both wet and dry pit types available in capacities up to 3180 GPM, heads to 290 ft. Single and duplex units. Full automatic control. Modern design using standard parts permits quick shipment at most economical cost.

BULLETIN 726.2.

PROCESS

Especially designed for handling corrosive liquids in the chemical process and allied industries. Normally supplied in 316 stainless steel constructions but materials to suit user's requirements can be furnished on application.

Capacities to 720 GPM. Heads to 190 ft. For heavy-duty service under most severe applications.

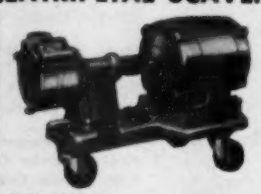
BULLETIN 727.1.

CLOSE-CUPLD CENTRIFUGALS

Single-stage pumps built in 23 sizes with a capacity range from 5 to 2000 GPM and heads up to 400 ft. Embody top horizontal discharge, closed impeller, machined stuffing box, fully protected shaft. Wearing parts easily renewable.

FIG. 3655 — BULLETIN 710.1.

CENTRIPETAL SCAVENGER PUMP



Centripetal action lets it pump liquid, air, liquid and air. Use it for transfer, cleaning-up, or pilot plant operations. Compact, lightweight, portable. All-iron or stainless steel construction. Capacities to 60 GPM, heads to 80 ft.

FIG. 2520 — BULLETIN 725.6.

For more facts circle 337 on Reader Service card, p. 119

MEN WHO BUY VALVES for heavy-duty service quickly see the plus values in O-B plug type valves. Union ring reinforces centerpiece joint—stainless steel seat and plug are O-B-500-hardened—plug is self-leveling. Really rugged globe and angle valves that lick your toughest problems! Ask your distributor for the valve in the orange-and-black box.

OHIO BRASS COMPANY • Mansfield, Ohio

O-B VALVES

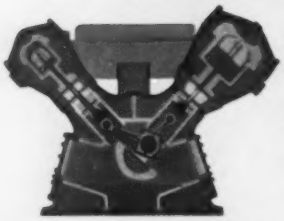
HOLAN

10075-V

For more facts circle 202 on Reader Service card, p. 119

Will your next Y-type compressor have all of these

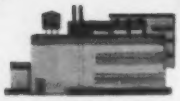
HIDDEN VALUES?



Frankly, it won't! Twenty-four of the values contribute to Worthington Y-type compressor performance. The other is fictitious—to see if you know enough about compressor quality to identify it. See page 231 for the *real* fictitious feature.

As you decide which 24 values are real, remember that they're not the obvious characteristics that show up on pressure gauges or price tables. They are true "values" that reveal themselves in your maintenance records ten years hence—when you find out that "those Worthington's are least expensive to run." Next time you specify a compressor, please see your local Worthington representative. Worthington Corporation, Compressor and Engine Division, Buffalo, N. Y. 36-9

WORTHINGTON

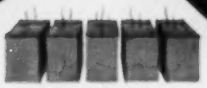


$1,000,000 ADDITION TO LABORATORY assures sound equipment designs based on actual research.

COMPOSITION TEST determines constituents of molten iron in each ladle before any casting is poured.

OPTIC COMPARATOR is used to check connecting rod bolt threads for uniform angles, lead and form.

MAGNAFLUX AND MAGNAGLO inspections are widely used to expose surface imperfections.



PARCO-LUBRITING of critical wearing surfaces completely eliminates most start-up scuffing problems.

2000 CRAFTSMEN, these units built by same men who design and build large 5000 hp, 15,000 psi units.

COUNTERWEIGHTED CRAFTSHAFT eliminates vibration and insures a smoother operation.

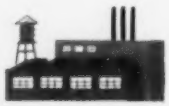
SELF-CLEANING OIL FILTER turns continuously to insure clean oil for pressure lubricating system.

ACCESSIBILITY – valves, packing and main parts are easily observed and reached by operators.

FAST SHIPMENT– two-stage 100-125 psi units are continuously stocked items, for quick shipment.

WATER-COOLED CRANKCASE keeps oil and compressor running gear at proper temperature.

CAPACITY CONTROL by-pass unloading, cool-operating suction valve unloaders, 3 step or 5 step option.



INTEGRATED DIV. includes foundry, manufacturing, sales, service and engineering in one location.

DESTRUCTION TEST of complete compressor cylinders verifies engineers' design calculations.

ASME DESIGN INTERCOOLER of straight tube construction externally mounted, is readily accessible.

CHOICE OF DRIVE – Flange mounted, Multi-V belt or direct coupled with tapered shaft, easy mounting.

ARTICULATED CONNECTING ROD reduces crankshaft length, reduces weight and gives fewer parts.

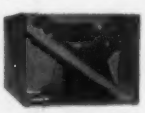
FEATHER VALVE – industry's preferred compressor valve—is efficient, quiet, and low in maintenance.

SALES AND SERVICE INTEGRATION recognizes kinship of one to the other. One man administers both.

HONING of connecting rod crankpin and crosshead pin ends results in tighter fits, no loose shells.

PROFILOMETER inspection of highly finished parts assures easy break-in and long life.

ADJUSTABLE ROLLER MAIN BEARINGS feature low friction losses which help to extend compressor life.



PACKAGE UNIT shipped assembled—factory alignment unchanged and no field adjustment needed.

REMOVABLE DOWEL locks piston rod to crosshead—prevents turning due to loosened crosshead nut.

ULTRASONIC TEST– an advanced method of examining certain critical parts for internal quality.